The Role of Practical Laboratory Work in Bridging Programmes for Chemical Technicians

J T LAFFERTY

October 1999

An investigation of the role of practical laboratory work in bridging programmes for chemical technicians in technikons in South Africa, with particular reference to Mangosuthu Technikon.

J T LAFFERTY

Dissertation submitted in compliance with the requirements for the Master's Degree in Technology

in the department of
Education

at
TECHNIKON NATAL

SUPERVISOR: JM GARDNER BA, BEd, PhD

APPROVED FOR FINAL SUBMISSION:

Dr JM Gardner
SUPERVISOR

23 October 1999

DECLARATION

I declare that:
this dissertation represents my own work, both in conception and execution.

All the sources I have used or quoted have been indicated and acknowledged by means of complete references.

JANICE THERESA LAFFERTY
22 October 1999

ACKNOWLEDGEMENTS

This dissertation has been an interesting venture. I have enjoyed collecting and writing up this dissertation. The process has been informative as well as a worthwhile learning curve for me.

Now that this work is complete, I can reflect on the past three years and be thankful to so many people who have made my work easier. When support is offered readily, this assistance is welcomed and the task at hand is made manageable.

The Library staff at Technikon Natal are to be commended for their assistance with the literature search I embarked upon. The promptness and the accuracy of the service were welcomed.

My own staff in the Chemistry Laboratories have been most supportive of my work and the time that has been needed to dedicate myself to the tasks. I also take this opportunity to register my appreciation to The Head of the Chemistry Department, the Staff Development Unit and so many other colleagues on the staff body who have given me encouragement.

Naturally my endeavours to contact the various tertiary institutions were mixed with success and failure. Those institutions however who did respond so readily are to be thanked for this assistance. It was appreciated. It is hoped that whatever I have gained from this effort might be useful to colleagues in the tertiary system who are interested in the bridging courses. I would also like to express gratitude to the various Company representatives who not only answered questionnaires but also allowed me to visit the companies.

My family and friends provided me with support and encouragement. For this I am most grateful.

Finally I would like to thank Dr John Gardner for being an enlightening and supportive supervisor ensuring that I worked consistently at the tasks set. I have learnt so much about the research process from him. I have also learnt from my supervisor that, what I set out to do I would be able to accomplish.

The work I have done on this dissertation has been a rewarding experience.

Thank You

ABSTRACT

TOPIC: An investigation of the role of practical laboratory work in bridging programmes for chemical technicians in technikons in South Africa, with particular reference to Mangosuthu Technikon.

This research considers the role of introductory practical laboratory work, in a bridging course, in the success or otherwise of vocationally orientated students at technikons in South Africa.

Mangosuthu Technikon, on which the study focuses, provides mainly for students whose educational background has ill-prepared them for the demands of tertiary studies. Besides the disadvantage of studying through the medium of English, students in the Engineering Schools are further hampered in their studies by having inadequate practical skills for laboratory work. The need to redress the problem of access to tertiary education has resulted in the introduction and continued use of bridging courses for educationally disadvantaged students. Since the secondary education system does not appear to be improving substantially, it would appear that the bridging courses will remain a necessity for some time.

Initially Mangosuthu Technikon offered a school/discipline bridging programme (Pre-Technican Course) for aspirant Engineering students, which allowed disadvantaged applicants a second chance to access tertiary education. It was an intensive six months' course, comprising experiential learning in the integrated components of Mathematics, Communication, Physics and Chemistry. The latter two subjects incorporated a substantial practical component. In the interests of rationalisation, a general Access Course replaced the former course in 1994. The emphasis became largely focussed on theoretical rather than practical work. After initial research indicated that the role of practical laboratory work in the training of chemical technicians in technikons in South Africa was of consequence, a practically orientated bridging course was reintroduced in 1995.

This dissertation shows that an educationally disadvantaged student who aspires to becoming a chemical technician requires an holistic education, at the Mangosuthu Technikon bridging course level, which incorporates relevant theoretical and practical components, in order to procure, and succeed in, tertiary education. Such practical work is a prerequisite for aspirant chemical technicians if they are to satisfy the needs of tertiary programmes and the demands of their future employers. Findings throughout the dissertation show that practical work is of consequence. Technikon and Industry representatives confirm their commitment to the inclusion of practical work in bridging courses. The implementation and administration of practical bridging courses also play important roles in ensuring that disadvantaged students gain access to tertiary education.

This study evaluates Mangosuthu Technikon's original Pre-Technician Course, its 1994 general Access Course and its subsequent Pre-Technician Courses, and finds that Pre-Technician Course (1989/1990) students performed well and that the majority of them were able to access tertiary education and cope with its demands reasonably well. The Access Course (1994) students, by comparison, performed dismally. Years subsequent to 1994 have seen an improvement in the pass rates, but not to the level of 1989/1990. The study, thus, concludes that practically orientated bridging courses impact significantly on successful performance in formal courses for technicians.

CONTENTS

CHAPTER 1

INTRODUCTION

THE PROBLEM AND ITS SETTING

CHAPTER 4

THE DESIGN OF THE MEASURING INSTRUMENT

CHAPTER 5

TECHNIKONS

CHAPTER 6

THE REQUIREMENTS OF THE CHEMICAL INDUSTRY

CHAPTER 7

MANGOSUTHU TECHNIKON'S BRIDGING COURSES

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 7

APPENDICES

CHAPTER ONE

INTRODUCTION

THE PROBLEM AND ITS SETTING

1

1.1 INTRODUCTION

1.1.1 TOPIC

An investigation into the role of practical laboratory work in academic bridging programmes for chemical technicians in technikons in South Africa, with particular reference to Mangosuthu Technikon.

1.1.2 THE RESEARCH PROBLEM

1.1.2.1 STATEMENT OF THE PROBLEM

Mangosuthu Technikon, on which this study will be centred, caters mainly for students whose educational background has ill prepared them for the demands of tertiary studies. Besides their language disadvantage in English, students in the Engineering Schools are further hampered in their studies by having inadequate practical skills for laboratory work.

Initially, a generic bridging programme was offered by Mangosuthu Technikon for the engineering schools. As the technikon expanded, the course became school specific. The Pre-Technician Course offered in the School of Chemistry and Chemical Engineering was an intensive six- month programme. It involved experiential learning in the integrated components of Mathematics, Communication, Physics and Chemistry. The latter two subjects incorporated a substantial practical component. Students registered for chemical engineering had, besides these subjects, instruction in technical drawing. In 1993 entrepreneurial development was included. At the start of 1994 yet another change to the bridging course was made, almost involving a reversion. The Access Course as it is named became a general course for all students registering with the engineering schools. This change was in the interests of rationalisation i.e. for financial reasons.

The emphasis fell more on theory than on practical work.

This research identifies the role of practical laboratory work in the training of chemical technicians in technikons in South Africa. The project also evaluates the importance of practical laboratory work in the training of chemical technicians.

This research involves an evaluation of the Access programme (1994) and the preceding Pre-Technician programmes of Mangosuthu Technikon, which will be useful for the development of an effective bridging programme for students in Chemistry, not only at Mangosuthu Technikon but also at other technikons in South Africa.

1.1.3 THE SUBPROBLEMS

1.1.3.1 Subproblem 1

To demonstrate the need for a bridging course

The first subproblem was to determine the effectiveness of the secondary education obtained by potential tertiary students. Tertiary education demands that students about to embark on further studies should have acquired a certain amount of formal knowledge and skill. In addition to this Jeff Jawitz (1993) writes that, by implication, these students should have an undefined body of knowledge, experience of technology and ideally have

> spent most of their childhood playing with mechanical and electrical toys lived in an urban environment and have electricity and electrical appliances in their home, lived near water and have seen a variety of petrol and wind-powered crafts, used a lift in a very tall building, walked or skated on ice..........to mention a few (Jawitz, 1993:2; punctuation [sic]).

Unfortunately most black South African students do not fit that profile, which seriously hampers their future performance and, in particular, their technical studies. Other "educational disadvantages suffered by black pupils under Apartheid" according to Jeffrey Hillman (1990) "are well known and have been widely reported: overcrowded and poorly equipped classrooms, unqualified teachers, and a lack of laboratories, are but a few of the more obvious ones" (Hillman, 1990:2).

Although new secondary school models and/or teaching curricula are currently being devised and implemented, the need to 'bridge the gap' to tertiary education remains. Potential chemical technicians need to gain access to formal courses at technikons. The available bridging courses need to address the inadequacies of prior learning. It is envisaged by the writer that the recommendations for a practically oriented bridging course which will be made later in this work, will address such problems and allow more students to access tertiary education and to achieve success therein.

1.1.3.2 Subproblem 2

To evaluate such present(or past) courses

The second subproblem was to evaluate bridging courses, with particular reference to the practical laboratory components of the bridging courses on offer at technikons.

Initially the bridging course offered by Mangosuthu Technikon was a generic one for the Engineering schools. As the technikon expanded, the course became school specific. The Pre-Technician Course offered in the School of Chemistry and Chemical Engineering was an intensive six-month course. It involved experiential learning in the integrated components of Mathematics, Communication, Physics and Chemistry. The latter two subjects incorporated a substantial practical component. Students registered for chemical engineering, had besides these subjects, instruction in technical drawing. In 1993 entrepreneurial development was included.

At the start of 1994 the bridging course was changed again. The Access Course (as it was named) became a general course for all students registering with the engineering schools. This change was in the interests of rationalisation (i.e. for financial reasons). The emphasis was largely on the theoretical rather than on the practical aspect. This course lasted (fortunately) for one year only and was changed again in 1995. The revised course, as will be documented, was once again practically oriented but the negative aspects of the Access Course, such as contact hours outside normal campus hours and the use of contract staff, still prevailed.

The writer has endeavoured throughout this work to identify the role of practical laboratory work in the training of chemical technicians in technikons in South Africa. It has also been the writer's concern to evaluate the importance of practical laboratory work which, according to Christofi and Davies (1992), is one of a variety of learning styles which they suggest make good educational sense. Christofi and Davies (1992) go on to emphasise that "not only is variety of approach refreshing and motivating for students but, from a cognitive point of view, different students learn better in different ways. The methods teachers employ in order to encourage students to explore curriculum areas are numerous. In science, these include problem solving, experimentation, discussion, library research, fieldwork, worksheets, role-play, art work etc" (Christofi and Davies, 1992:14).

The research that the writer carried out involved an evaluation of the 1994 Access Course, the Pre-Technician Course (1989/1990) and the Pre-Technician Course (1995 onwards) of Mangosuthu Technikon (see Chapter 7). The writer also investigated the various bridging courses on offer at tertiary institutions throughout South Africa to assess the role of practical work in their courses (see Chapter 5). The writer and most personnel involved in bridging courses favour an integrated curriculum for the educationally disadvantaged students. Not only would such a course equip students with the necessary skills required for academic success (simultaneously allowing more students access to mainstream studies at the institution), but the course would also enhance student employment opportunities and career aspirations. The chemical industry requires students to have had varied learning situations and practical work, which acts as a "vehicle for developing general skills" (Royal Society of Chemistry, 1992:3).

1.1.3.3 Subproblem 3

To analyze the demands of industry for the training of chemical technicians

The third subproblem was to analyse the needs of industry regarding the practical training of future technicians. Lindeque (1993) reports that now is the time for educators to "enter the world of the employer and the employee in the work situation" (Lindeque, 1993:6). He also states that students are not equipped with the required job skills and asks that technikons take a "leading role in developing an integrated approach to education and training in South Africa" (Lindeque, 1993:6). This research will study in particular the practical training component of a bridging course and examine the effect of such training with regard to the further studies or experiential training of chemical technicians.

The demands of industry and the role of practical work in the training of potential chemical technicians will be investigated by the writer (see Chapter 6).

The Draft Policy on Education and Training (1994) points out that as a result of the previous education system in South Africa there exist "huge inequalities in skills and competencies in the nation's labour force" (Draft Policy, 1994:3). These inequalities need to be eradicated. This research has identified that there is a need for support from industry regarding practical tuition. ICI (Britain) spokesperson John Monaghan confirmed his support for practical tuition when he reported that "industry would resist any diminution in the time spent on practical work" (in Education in Chemistry, 1992:3). In his own words the practical training of a technician is important: "Practical skills should be the selling point, the added prize" (in Education in Chemistry, 1992:3).

The writer is of the opinion that there is insufficient influence from industry on the practical tuition of potential chemical technicians. It is recommended by this writer that technikons, the community and local industry work closely together, in order to determine the input required from industry and the necessary changes to technician courses to achieve a fully integrated curriculum not only at the bridging course level but throughout the formal courses too.

1.1.3.4 Subproblem 4

To propose a suitable curriculum for chemical technicians

The final subproblem was to propose a suitably integrative bridging curriculum for chemical technicians at Mangosuthu Technikon and other technikons in South Africa.

Such proposals are discussed throughout the following sections of this work. The writer reiterates that without the support of management, staff, students and other relevant role players, bridging courses will not be successful. Dedication and commitment to working towards the objectives of a successful bridging course must be a priority at all times.

1.1.4 MOTIVATION FOR THE RESEARCH

The writer was motivated to carry out this research as a result of the poor performances by students emerging from the 1994 Access Course. The eradication of practical work and the subsequent problems encountered by students led the writer to research that situation (Lafferty, 1995). Initial findings from that research project showed that a lack of practical work was of consequence. The writer believes that those findings led the course designers to rethink the role of practical work for chemical technicians and that provided motivation to pursue more thorough research into the matter.

It is hoped that this research will lead to the design of a bridging programme that will consciously apply effective teaching and learning principles (Scott, 1994:3) and impact on the curriculum and its objectives as a whole.

1.1.5 SCOPE OF THE RESEARCH

Research into the secondary schooling system is a pre-requisite for understanding the necessity of developing a suitable bridging programme incorporating a practical component for chemical technicians. The research, however, cannot resolve problems within the education system. The information will be used to develop an adequate support programme for students trying to gain access to further formal tertiary education. Examinations and criteria for promotion in the bridging programmes will not be examined in detail. The research will be limited to the chemistry practical component of the bridging courses, course content, student evaluation and criteria for promotion. The study, which will include some research into staffing and funding, will not consider the financial implications of operating a bridging course. Other technikon bridging courses will be analysed but the emphasis of the project will consist in an evaluation of the two different bridging programmes that Mangosuthu Technikon has offered.

1.1.6 UNDERLYING ASSUMPTION

For the purpose of this research it must be assumed that, for future planning, an ongoing and increasing need will remain for bridging programmes (after Crisp 1990). As written in the Draft Policy for Education and Training (1994) there will be no quick and easy solution to the deep-rooted educational problems of this country. See Chapter 2 for a detailed treatment of this issue.

1.1.7 HYPOTHESES

Hypothesis 1

Mangosuthu Technikon, will develop suitable bridging courses through improved articulation with its surrounding community.

Such bridging courses will address the inadequacies of the schooling system and ensure that the approach to curriculum development focuses on the principle of life-long learning and student upliftment. The course content will enable the student to achieve greater mobility in the education and training system.

Hypothesis 2

The emphasis on practical laboratory work for technicians in technikons will need to be maintained in bridging programmes.

The various bridging programmes could be seen as challenging what Prof I Scott (1994) regards as the "basic structural elements of degree and diploma programmes " which "seem to be regarded by many academics as immutable" (Scott, 1994:3).

Hypothesis 3

Demands from industry will favour the inclusion of relevant industry-related practical tuition for chemical technicians.

1.1.8 RESEARCH METHOD

Evaluation of the past Pre-Technician bridging course (which was school specific, incorporating practical work relevant to the course studies) and the 1994 Access Course (a general programme with no practical work) will be carried out to ascertain whether practical training in the bridging programme would enhance the adaptation of students to their tertiary career. The project will aim to establish a communications base with the chemical industry concerning its requirements in terms of the skills of a chemical technician. On completion of the research for this study, changes to the bridging course will be proposed and suggestions made for the formulation of an effective bridging course for chemical technicians at technikons in South Africa.

1.1.8.1 Collection and evaluation of documentary information:

1.1.8.1.1 Library searches on the topic were made.

1.1.8.1.2 Recent research in this area were identified.

1.1.8.1.3 Similar programmes at technikons in South Africa were studied, by

1.1.8.1.3.1 visits to the various institutions to establish the programmes in use;

1.1.8.1.3.2 analysis of programmes' objectives; and

1.1.8.1.3.3 establishment of what evaluations had been carried out at the institutions considered.

The research methods will consist of a survey, using questionnaires and partially structured interviews.

1.1.8.2 Curriculum Analysis

1.1.8.2.1 This part of the research included the collection and analysis of all relevant data concerning course content and practical content included in the previous Pre-Technician Course (bridging programme) as well as that of the Access programme. The role of the practical component of the previous course will be evaluated and then the objective for the inclusion of practical tuition in that particular programme will be determined.

1.1.8.2.2 Collections of past and present student results from the bridging programmes through to completion of studies were considered. Where possible, collection of the same sets of results from other technikons are made for the purpose of comparison.

Past course:	results from 1989 to 1990
Access Course:	results from 1994
Present course:	results from 1995 to 1997

1.1.8.2.3 The analysis of results includes: the number of students successfully entering the recognised tertiary diploma course as a result of the bridging course, and the success rates of those students throughout their diploma courses.

1.1.8.3 Analysis of testing and examination methods for practical work:

1.1.8.3.1 Identification of attendance requirements set for students.

1.1.8.3.2 Analysis of what quantitative and/or qualitative methods are used for testing/examining. This will ascertain the importance placed on a student's passing the practical component of the course.

1.1.8.4 Fieldwork

1.1.8.4.1 Questionnaire Survey:

1.1.8.4.1.1 The researcher designed and sent questionnaires to Pre-Technicians who had attended secondary schools within the main intake area of Mangosuthu Technikon with a view to:

1.1.8.4.1.1.1 ascertaining the facilities available for practical work

1.1.8.4.1.1.2 gaining insight into the experience and knowledge (pertinent to practical tuition) of teachers at the relevant schools.

1.1.8.4.1.1.3 determining the actual level of competence a student has for practical work when entering the technikon.

1.1.8.4.1.2 Questionnaires were sent out to students from the past and present courses. The researcher attempted to interview a random selection of students from the bridging course of the past, as well as students busy with the present course, for feedback on students' attitudes towards practical work and its impact on their studies and future industrial work.

1.1.8.4.1.3 The researcher sent out questionnaires and undertook visits to various chemical industries (those that specifically offer experiential training to technikon students) in order to establish contact with industry and assess its perceptions of technicians in industry. The responses have enabled course content to be evaluated relative to the specific technical skills required by industry.

1.1.8.5 Visits to Technikons, NGOs and The Chemical Industry:

The researcher interviewed staff involved in bridging programmes (Technikons and NGOs) and staff supervising chemical technicians (the chemical industry).

A basic interview structure and workplan was followed by the researcher during those visits and full explanation of this research was given to the various departments visited .

1.1.8.5.1 The researcher explained the purpose of the study. The time was also used to follow up on the questionnaires.

1.1.8.5.2 Through enquiry into the general character of the various bridging programmes the researcher was able to ascertain common concerns in Science teaching. Discussions were held with industry personnel concerning their expectations of experiential trainees.

1.1.8.5.3 Through interviews the researcher ascertained the work undertaken in bridging programmes.

1.1.8.5.4 Information about the attitudes of Science lecturers to practical work was gained through this work plan. This insight was necessary to assess the commitment of staff to bridging courses.

1.1.8.5.5 During these interviews the researcher requested quantitative data about the bridging programmes from the technikons, and NGOs, relating to numbers of students, subjects offered (in particular their practical component contents), lecture time for each subject, assessment methods, pass requirements, and evaluations of particular courses.

1.1.8.5.6 A link between technikons and industry was established for any subsequent studies.

1.1.8.6 Nature of desired observations:

1.1.8.6.1 When observing practical lessons offered by the technikons, and NGOs, the researcher asked the students questions relating to the practical work as well as to the course in general.

1.1.8.6.2 When observing chemical technicians at work the researcher asked questions relevant to the skills they were displaying as well as questions about their experiential training.

1.1.8.6.3 Unstructured - ad hoc visits, where possible, took place to practical lessons and to the various industries where technikon students are employed, in order to observe students.

1.1.8.7 Course evaluations:

1.1.8.7.1 The researcher evaluated the success of the past bridging programme by considering the student pass rate over the entire course. The results of students in the present bridging programme were also evaluated, and their success as they proceeded through the formal tertiary diploma course was traced.

1.1.8.7.2 The researcher evaluated Mangosuthu Technikon's past and present bridging programmes comparatively.

1.1.8.7.3 The researcher, where possible, analyzed the evaluations of bridging programmes of other technikons and NGOs.

1.1.8.7.4 The researcher evaluated the success of practical work in relation to the needs of the chemical industry.

1.1.8.8 Proposal for a new model of tuition for the under prepared technical student

The researcher has provided guidelines for the restructuring of practically oriented science courses for under-prepared technikon students. If and when a revised bridging course is devised, an evaluation programme should be implemented to continuously assess and (where necessary) adjust the course, to ensure that success is sustainable.

1.2 THE PROBLEM

The problems associated with the transition from pre-tertiary education to tertiary education are international and well documented. South Africa's problems and difficulties have increased during the past decade. Problems such as lack of facilities and qualified teachers within the secondary schooling phase have ill-prepared students for tertiary education and are the result of "historical factors which have worsened because of the political and socioeconomic restraints of the earlier apartheid years" (AUT, October 1992:1).

For a tertiary study programme to be effective the students who participate should be willing to learn and be in possession of the necessary skills and so progress to the various levels of tuition deemed necessary to that programme. The programmes offered in South African tertiary education are faced with challenges, particularly concerning the transition process from pre-tertiary to tertiary education. The high failure rate of black first year students is cause for concern. The majority of black pupils come from disadvantaged backgrounds, compounding their being under-prepared for tertiary education.

> Not only are valuable resources lost in this way but the high costs attached to unsuccessful study are a source of great concern for the State, the individual and the institutions concerned (AUT, 1992:1).

1.2.1 HISTORICAL IMBALANCES

The historical imbalances of the past in South Africa have left their scars on education. The inadequate schooling system, of which many black students in this country have been products, has left them unprepared for the future. A graphical representation (see Appendix 1) constructed by the writer from data collected (1990 to 1994, which was the last time such data from the 17 different education departments was available), clearly shows the appalling results of black matriculants as opposed to their white peers. In order not to lower academic standards or lower entrance requirements for the formal courses it has been necessary to introduce systems which would assist these particular students. The students who desired to follow a career path in the sciences yet who did not meet the necessary entrance requirements or were considered to be 'at risk' have to be assisted by some system to ensure they are given a firm foundation for their tertiary study programme. The need for such bridging and support systems for such students will remain a priority.

1.2.2 PRE TERTIARY EDUCATION SITUATION

The majority of technikon students are at a disadvantage for many reasons. One of these is that the language of instruction is English, which is not their home language. This and other conditions under which black students have studied during the apartheid era have "resulted in an unacceptable failure rate amongst learners across the whole spectrum of black education" (Education and Training White Paper Committee, 1994:16). These include crowded conditions, insufficiently trained teachers - 85% underqualified and unqualified (after Gounden & Mkhize, 1991), inadequate physical facilities at schools, unmotivated pupils and teachers, difficult political and socioeconomic circumstances and a lack of science laboratories and resource facilities. Studies in Australia, where science facilities are generally good, have found "a positive association between student's attitudes and school facilities" (Hegarty-Hazel, 1990:139). This unacceptable failure rate amongst learners across the whole spectrum of black education" (Education and Training White Paper Committee, 1994:16). These include crowded conditions, insufficiently trained teachers - 85% underqualified and unqualified (after Gounden & Mkhize, 1991), inadequate physical facilities at schools, unmotivated pupils and teachers, difficult political and socioeconomic circumstances and a lack of science laboratories and resource facilities. Studies in Australia, where science facilities are generally good, have found "a positive association between student's attitudes and school facilities" (Hegarty-Hazel, 1990:139). This would mean that the majority of secondary pupils in South Africa would have unfavourable attitudes towards the sciences. The existing Science syllabus has also been criticised as being "outmoded, academic and content-driven" (Rolnick, 1995:3). These factors do not augur well for a pupil wanting to embark on a successful tertiary education.

The Draft Policy for Education and Training issued by the Education and Training White Paper Committee (1994) stresses that the education system available to the majority of black students in South Africa has entrenched in it "huge disparities in physical facilities, professional services, and teaching quality" (Education and Training Committee 1994:2). Such historical inhibitions on potential tertiary Chemistry students necessitate the introduction of a suitably integrated bridging curriculum which will allow students to access tertiary education more successfully. Past matriculation results indicate that suitable action in this regard must be adopted. From 1989 to 1994, an average of only 43,9% of all black pupils who wrote Senior Certificate examinations actually passed. Only 10,9% of all black pupils attained matriculation exemption (RIEP, 1994, Vol. 15:12). (See Appendix 2).

Data collection in 1995 faced problems in the new South Africa as it was the first time that educational data was collected by non-racial education departments which were newly formed. Obviously data collection by race was now sensitive and as a result, only a general pass rate (%)

and number of passes has been declared in the Education and Manpower Development Publication for 1995. The pass rate in the nine provinces varies from 39% in the Northern Province to 77% in KwaZulu-Natal (RIEP,1995,Vol. 16:11). (See Appendix 3).

The figures for matriculation grades published in the Education and Manpower booklet for 1996 gives results from 1994 to 1996 and once again the failure rate is high (RIEP, 1996, Vol. 17:11). (See Appendix 3).

The matriculation record of first-year Engineering students at two “historically black” tertiary institutions (Technikon Northern Gauteng and Mangosuthu Technikon) was collected by the writer and are given as Tables 1 - 4 below to corroborate the preceding paragraph. Technikon Northern Gauteng (TNG) supplied these matric grades which are the total grades collected from students enrolling at that Technikon for the years given. Students attending the Pre-Technician Course at Mangosuthu Technikon (MT) in Semester One and Semester Two of 1995 as well as Semester One of 1996 were also asked to fill in a questionnaire so that the matriculation results could be recorded, and it is these that appear in Tables 1 - 4 with the TNG results.

These results were also kept by the writer so as to compare the results obtained by the students at the completion of the bridging course, as will be discussed in Chapter Seven.

The data in Tables 1 - 4 emphasises the need for a form of bridging to be made available to students with inadequate grades so as not to ‘lose’ them from the formal system.

TABLE 1 TNG and MT MATRIC GRADES FOR MATHEMATICS (HG)

(All grades expressed as % of the total for that column)

GRADE	TNG 1992	TNG 1993	TNG 1994	MT 1994	MT 1995/1	MT 1995/2	MT 1996
A:	0	0.3	0	0	0	0	0
B:	0.01	0	0.1	3	0	0	1.5
C:	3	6	7	3	3	2	9.5
D:	22	17	20	20	12	4	21
E:	50	53	61	50	30	21.5	30
F:	14	17.5	6	21	3	2	0
FF:	0.4	0.6	0	0	0	0	0
G:	8	3	0.4	0	0	0	0
GG:	0	0.8	3.1	0	0	0	0
H:	2	2.2	1.8	3	0	0	0

It is clear that the greatest % of the total is the E grades at TNG and MT

TABLE 2: TNG and MT MATRIC GRADES FOR MATHEMATICS (SG)

GRADE	TNG 1992	TNG 1993	TNG 1994	MT 1994	MT 1995/1	MT 1995/2	MT 1996
A	0.8	3	1	0	0	0	0
B	2	2	1	2	0	0	5
C	7	12	9	9	1	0	8
D	20	17	15	8	9	11	12.5
E	45	43	39	33	34	32	11
F	24	19	35	46	8	25	1.5
FF	0.8	0.7	0	0	0	0	0
G	0	2.2	0	1	0	0	0
H	1.6	2.2	0.7	0	0	0	0

The E and F grades are the in the majority again. Such grades would not allow students to enter the formal courses.

TABLE 3: TNG and MT MATRIC GRADES FOR PHYSICAL SCIENCE (HG)

GRADE	TNG 1992	TNG 1993	TNG 1994	MT 1994	MT 1995/1	MT 1995/2	MT 1996
A	0.2	0.2	0.1	0	0	0	0
B	0.5	0.4	0.3	0	0	0	0
C	5	4	4	3	0	0	3
D	17	12	16	13	30.6	18.6	21
E	58	64	62	72	69.4	72	55.5
F	12	14	11	10	0	7	0
G	6	3	2	1	0	2.4	0
GG		2	2	0	0	0	0
H	1.5	0.4	1.5	1	0	0	0
HH		0.1	0.2	0	0	0	0

TABLE 4 TNG and MT MATRIC GRADES FOR PHYSICAL SCIENCE (SG)

GRADE	TNG 1992	TNG 1993	TNG 1994	MT 1994	MT 1995/1	MT 1995/2	MT 1996
A	0	0.1	0	0	0	0	0
B	0.6	0	0.2	0	0	0	0
C	3	3	2	0	0	4	3
D	8	9	7	16	25	13	9.5
E	50	47	47	45	58	57	8
F	35	38	41	38	17	26	0
G	3	2	1.5	0	0	0	0
GG		0.3	0.2	0	0	0	0
H	0.4	0.3	0.2	0	0	0	0

The highest number of grades is for the E and F grades

Another grave problem for black students who are enrolled in the disadvantaged secondary schooling situation, is that the subject choices for the final school year are not suitable for entry to the job market; such students are not trained for a job but require extra training (RIEP, 1994:12). Mathematics and Science are not popular choices among this group; in fact, of 350 000 Black candidates throughout the country in 1993 only 15,83% selected Science and 27,34% selected Mathematics. In 1994, 18,1% selected Science and 32,89% selected Mathematics. In comparison, of white Std 10 pupils in 1992, 48,26% selected Science and 71,15% selected Mathematics and in 1993, 49,61% selected Science and 73,22% Mathematics (RIEP, 1994:10). The majority of Black candidates are not successful in their final examinations and on average over the past five years, only 6,3% have passed Science annually and 9,9% passed Mathematics. The figures published in the Education and Manpower booklet for 1996 show that the Mathematics and Physical Science results for all the provinces "leave much to be desired" (RIEP, 1996:12). The percentage of students who failed those two subjects varies among the nine provinces from 10% to as much as 80%.

It is important to realise that a pass does not guarantee selection for tertiary education. The requirements set by tertiary institutions for entrance into the formal courses can be seen below. That means that black students' matriculation results are frequently inadequate to meet the entrance requirements of most tertiary institutions.

For entrance to formal studies the following achievement levels are required in Mathematics and Physical Science		For entrance to bridging programme
Technikons		
Peninsula:	Min D (SG) or E(HG)	No course available
Pretoria:	Min D (HG)	Maths & Science & Test of Potential
Witwatersrand:	Min D (HG) or Min C (SG)	Min E (SG) - inflexible
Port Elizabeth:	Min D (SG)	Maths & Science & HSRC aptitude testing
Free State:	Min D (HG)	Matric pass Maths & Science and Min 12 points on Swedish Scale
ML Sultan:	Min D (HG) or Min C (SG)	Students not accepted directly into the formal course (S1 level) will have aptitude tests and then follow the augmented programme
Border:	Min D (HG)	Maths & Science & Min F (SG)
Mangosuthu:	Min D(HG)	Min E (SG) - flexible
TNG:	Min D (SG) or E(HG)	Min D & E (SG)
North West:	Min D (HG)	Min E (SG)
Natal:	Min E (HG)or C(SG)	No course but student support available
Cape:	Min D (SG)	Students not accepted for formal course but appear to have the potential to be successful.

E grades on HG in the majority of technikons are not acceptable for the formal courses. Consequently, for the majority of school-leavers wishing to enter a technikon, a bridging course would have to be available.

This problem of poor/inadequate schooling is causing other concerns in the academic world. In two separate newspaper reports, namely, *The Mercury* (20/6/96) and *The Sunday Times* (23/6/96), it is stated that academics at tertiary institutions complained of the "burgeoning number of students who needed individual tuition because of poor schooling" which was affecting research time for academics. In another "shock report" following an international testing programme in 1996 (The Third International Mathematics and Science Study) it was announced in Boston that South African children "are among the worst in the world when it comes to maths and science" and "woefully ill-equipped for the demands of a hi-tech global economy" (Barber in *The Sunday Times*, 23/6/96:1).

1.2.3 IMPORTANCE OF SECONDARY SCHOOLING IN RESPECT OF TERTIARY EDUCATION

School Science education is where students are first introduced to science. The characteristics of school Science which differentiates it from other subjects in the curriculum is that Science lessons normally take place in a science laboratory where practical investigations and demonstrations can take place and ensure interaction between teacher and student. The education students receive should aim to provide them with an understanding of not only the scientific laws governing the natural world but also of the processes of scientific inquiry. These two related factors will ensure understanding of the facts, concepts, laws and theories of accepted science as well as an appreciation of the ways in which some knowledge came to be established. The validity of the research and findings of science will then be accepted. Practical work is widely used then as a teaching strategy.

> Practical work in science, however, is usually not seen merely as a means towards the end of better content learning; it is also seen as crucial in developing an understanding of the procedures of scientific enquiry (Lubben & Millar, 1995:2).

A major change advocated by the curriculum reform in USA and United Kingdom and elsewhere, (Pinchas Tamir), "is a new conception of the role of the school laboratory no longer as merely illustrative and confirmatory adjunct to the learning of science concepts but, instead, as the centre of the instructional process" (in Woolnough, 1991:13).

1.2.3.1 Student Preferences

> It is equally clear that some learners do become better at carrying out science investigations as a result of their experience of school science. If this can occur as a consequence of relatively unstructured experiences of 'doing science', then it ought, surely, to be possible to improve the learning by better structuring and sequencing of experiences (Duggan et al, 1994:209).

Students at Mangosuthu Technikon who had not had the privilege of carrying out Physical Science experiments individually had indicated their desire to have done so. This is stressed throughout this dissertation from data collected by the writer.

It is worth noting that in a questionnaire given to Pre-Technician students by the writer in 1995 (See Appendix 4) the question was:

Would you have liked your school to have been involved with the Technikon or Technical College so as to allow you greater access to practical tuition? YES/NO

YES	NO
100	6

The same question was addressed to the S1 (first level of the formal course for chemical technicians) students in 1995 who had attended the general Access Course at Mangosuthu Technikon during 1994 and the responses collected from them were:

YES	NO
28	2

(See Appendix 5).

Gott and Duggan stress that students do remarkably well in investigative work (when given the opportunity) and that they thrive in that type of environment.

> Watts (1991) has also commented on the sense of empowerment and ownership that this kind of problem-solving generates (in Gott and Duggan, 1995:61).

The students involved in the above mentioned questionnaire however had no or limited experience of school science but did desire to be involved with such activities. They had a limited chance of becoming better at carrying out science investigations as a result of their lacking practical tuition.

Privileged school pupils around the world carry out scientific investigations which are practical tasks, involving strategy decisions, choice of apparatus, decisions about which measurements to take and interpretation of results. Development through such investigations prepares the students for the initial laboratory courses in tertiary education. This is clearly indicated in a paper by Beasley and Chant (1996). Their focus was on student perspectives on their skills development, when faced with a laboratory course. A significant finding emphasised that "High school chemistry courses develop at least a novice level of competence" in student laboratory psychomotor skills and students are confident in being able to follow instructions as well as in presenting data (Beasley and Chant, 1996:7). It is interesting to note, when comparing South African black students with their counterparts in other parts of the world, the time spent at relevant working stations. In the United Kingdom, "11 - 13 year olds typically spend over half their science lesson time engaged in practical work (Beatty and Woolnough 1982) and 16 - 18 year olds more than one third (Thompson 1975)" (in Woolnough, 1991:43).

Unfortunately, as discussed above, the majority of Black students in South Africa have not had the privilege of learning science in an exciting environment where science is brought to life with experiments and practical work. Poor working conditions and authoritarian methods of teaching do little to foster student centred learning. The disadvantages of such schooling become obvious when one reads that students learning about science should be doing investigations so as to understand the way scientists work, how to solve problems and how scientific discoveries are made (Gott and Duggan, 1995:24). By learning the techniques of scientific enquiry they gain insight into scientific theory.

It would be appropriate at this point to include findings concerning the availability of practical facilities for students at secondary schools in South Africa and whether students were involved with practical work while at school. The following table of results is from a questionnaire handed out to Pre-Technician students registered in 1995 (as described earlier) who were attending courses at Mangosuthu Technikon. Included here also are similar results obtained from students at some other technikons in South Africa. These institutions were helpful in distributing similar questionnaires to their Pre-Technician students.

1.2.3.2

RESULTS FROM A QUESTIONNAIRE SUBMITTED TO SCHOOL OF CHEMISTRY AND CHEMICAL ENGINEERING PRE-TECHNICIAN STUDENTS ON COMPLETION OF THEIR FIRST SEMESTER (JUNE 1995)

106 STUDENTS PARTICIPATED

Question	Yes	No	Unsure	Did not answer
Did you have a qualified Physical Science and Mathematics teacher in Std 9 and 10?	84	16	2	4
Did you have facilities at the school for practical science tuition?	52	54		
Were you able to get "hands-on" experience with practical work?	33	68		5
Were only "demonstrations" available?	70	35		1
Would you have liked your school to have been involved with the Technikon (or a Technical College) so as to allow you greater access to practical tuition? *The writer acknowledges that this question was biased towards a 'yes' answer*	100	6		
Do you think it would have helped you in further studies?	104	2		

These students lacked the opportunity for individual practical tuition yet the desire for such tuition is evident.

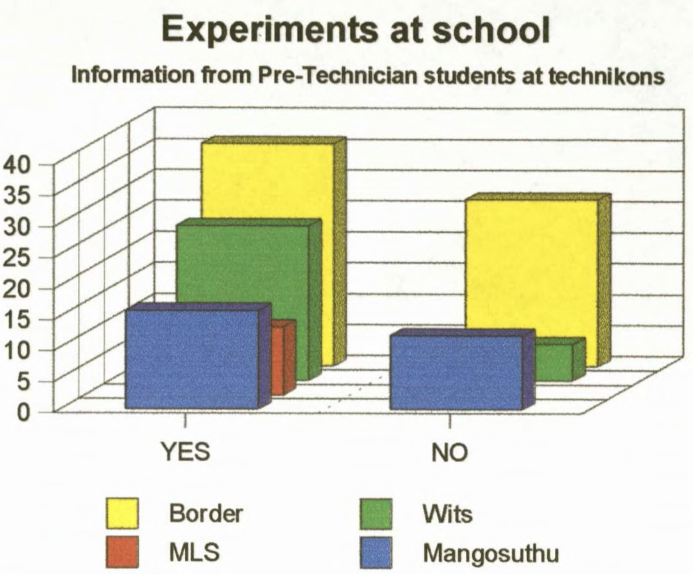
The following information was collected in 1997 from three other technikons as well as Mangosuthu Technikon. This information reiterates the findings from the Mangosuthu Technikon students questioned in 1995 and quoted previously. (This information appears again in Chapter 5 where the responses from questionnaires submitted to technikons are analysed).

Were Physical Science experiments conducted at your school?

Responses

Technikons	YES	NO
Border	36	27
Wits	25	6
MLS	11	
Mangosuthu	16	12
Total	88	45

Figure 1: Opportunity for experiencing Science practical work at secondary schools



Comments

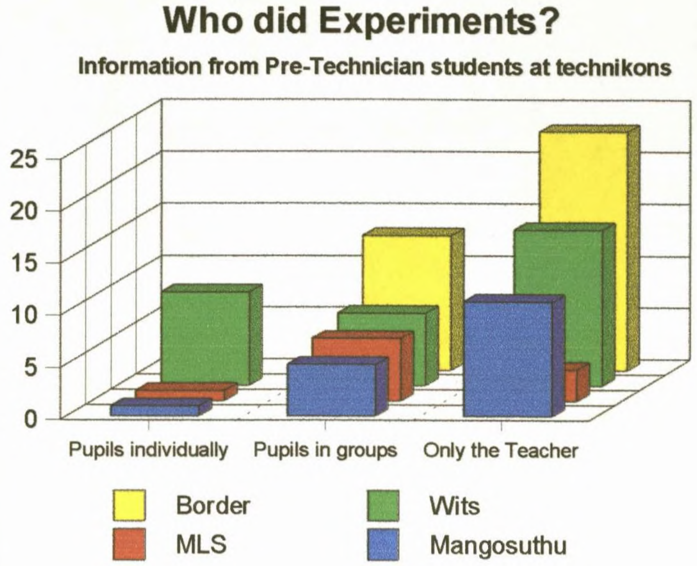
The table is encouraging in reporting that the majority of students at each tertiary institution were able to experience Physical Science experiments. The responses ratio, however, of 2:1 is unfavourable (i.e. 88 students responded affirmatively while 45 had not been so fortunate). This means that more than half of the pupils questioned did not have the opportunity of doing Physical Science experiments. These students would have been at an immediate disadvantage when attempting to undertake such practically oriented courses as Chemistry and Physics at the tertiary level.

If yes was answered to the above question, then who conducted the experiments?

Figure 2: The possibility of experiencing individual 'hands-on' practical work at secondary schools

RESPONSES

Technikon	Pupils individually	Pupils in groups	Only the Teacher
Border		13	23
Wits	9	7	15
MLS	1	6	3
Mango-suthu	1	5	11
Total	**11**	**31**	**52**



Comments

The above information clearly indicates that the majority of students questioned were unable to experience individual hands-on experiments. Unfortunately, of the total of 88 students who confirmed that they had experienced practical work at school, only 11 students did the practicals individually, while 31 worked in groups and the balance merely had a demonstration from a teacher. Once again the demands from the formal course of study for technicians would not have been met since the majority of these students had no or only a little hands-on experience. In a formal tertiary course they would need to know how to work independently.

The Centre for Education Policy Development (Gauteng) issued a booklet in January 1995 entitled *Curriculum Frameworks for Science, Technology and Mathematics*, aimed at redressing the outmoded syllabus in force at present. The existing syllabus does not take cognizance of the types of skills and attitudes needed to study science; consequently a new syllabus is envisaged so that on completion of the proposed General Education Certificate (GEC), a learner will be at a stage where he/she is trainable. On completion of the Further Education Certificate (FEC) a learner could attempt to access formal tertiary courses or enter the working world. Such a curriculum as envisaged in the document described above, will allow development or adaptation of skills, knowledge and attitudes needed to cope with the world in general. Science is seen as a participatory activity in which teachers and learners share responsibility for learning. Forward planning should emphasise the need for students to receive some sort of tuition which would enable them to redress the imbalances of the past, learn more actively and so be encouraged to study further in science and technology fields with confidence.

> This point was reinforced recently by an international survey on competitiveness which put South Africa last out of 46 countries in terms of standards in maths and science education (Barron in *The Sunday Times*, 23/6/96:7).

Programmes such as "bridging programmes", "access programmes" or "academic support programmes" are needed to address these weaknesses.

1.3 FACTORS INFLUENCING ATTITUDES TO SCIENCE

At this point it is important to consider factors influencing attitudes to Science since that will ultimately affect a student's learning of science and his/her performance in Science. Previously the writer has considered the effect of secondary schooling and the practical or lack of practical tuition on a student's ability to enter the formal tertiary education system and his/her subsequent performance. Brian Woolnough in his book *Effective Science Teaching* (1995), looked at the factors in depth. His findings from typical British schools, as a result of resources and facilities available to these schools, compare more favourably with the historically advantaged white schools in South Africa than with typical Black schools. It is evident that different types of education influence the success of the learner.

Students at schools with sufficient science facilities and resources are encouraged to plan their own experiments, to become involved with extended projects and to form linkages with industry. These schools also set up extracurricular science activities such as clubs and participate in science competitions.

Other encouragement factors are:

*good science teaching - where qualified and relevantly experienced teachers are involved;

*the nature of the science learning itself - its practical, challenging and problem-solving nature;

*extracurricular science activities;

*home background - where both parents are normally at home and encourage the learner, especially if the parents are normally educated and qualified in the science and

*engineering fields;

and of course,

* student ability.

Students from typical schools for Blacks (i.e schools which lack facilities and resources) will have been exposed to few favourable influences:

*teachers (as mentioned earlier) are not correctly qualified to nurture the scientific development of pupils;

*practical facilities are few if any, and the excitement garnered from direct involvement with science is nonexistent;

*since no practical work is available and there is minimal encouragement from teachers, extracurricular science activities would not be developed; and

*encouragement at home is minimal- the Black family unit in South Africa is not the typical unit found in most first world countries; the family unit would normally not be fortunate enough to have both parents present (in fact, in many cases grandparents are substitute parents) and few parents will be qualified in science or engineering.

A point that should be noted, according to authorities in practical science work, is that when students enter a laboratory they are "expected to do something with their hands, to observe, to measure, perhaps to smell, and from time to time even to plan, investigate and discover..." (Woolnough, 1991:13) which students in "advantaged" environments will be able to do, but "disadvantaged" students will not benefit from the environment in which he/she is learning. In addition,

> in regular classes students' attention may easily be diverted from the learning task, while the concrete nature of laboratory work helps students focus their attention on the task at hand... (Woolnough, 1991:13).

The "disadvantaged" student could well be diverted because of an unstimulating learning environment, while "advantaged" students would be better able to focus on the task at hand.

CASME and Link-Africa in an evaluation report on the success of their Schools Science Project in South Africa (which allows teachers to gain greater practical experience), point to improved motivation of teachers when they gain confidence in their ability to use practicals in their teaching. The project provided equipment for experiments as well as tutoring for teachers. (Report, CASME and Link-Africa, 1995:20). The quality of teachers is fundamental to "effective science teaching" (Woolnough, 1994:43) as it will influence the manner in which they impart their knowledge. Woolnough continues that "good science teachers are knowledgeable, competent and enthusiastic in their subject and in class management, and understanding and sympathetic to students and their needs" (Woolnough, 1994:43). Unfortunately, the majority of students entering historically Black institutions did not have teachers who were of that calibre (see reference to Report, Casme and Link-Africa, 1995 above).

In an attempt to assess factors influencing the attitude of students to practical work, studies have found that factors such as lack of adequate contact with staff, lack of suitable equipment and insufficient time for meaningful practical work definitely influenced students' attitudes. One survey determined that factors such as these are "possible hindrances to the enjoyment of practical work in chemistry" (Devenport et al., 1979:188).

"School science should be about learning to do science through scientific investigations" (Woolnough, 1995:33). Students "usually enjoy activities and practical work, and when they are offered and given a chance to experience meaningful and non-trivial experiences they become motivated and interested in science (Henry 1975, Lawson et al 1989)", (in Woolnough,1991:14). It is these activities which stimulate, challenge and fulfil students' needs. Another important factor, according to Driver and Bell (1985), is that laboratory work has the opportunity to be "conducive to the identification, diagnosis and remediation of students' misconceptions" (in Woolnough, 1991:14). All these factors which enhance the learning environment for students attempting to study Chemistry are sorely missing from the majority of South African learners' schooling environments and that has led to the present study, to determine the role practical work has in a learner's tertiary study programme.

1.4 TRANSITION PROBLEMS

In order to gain a full picture, it is necessary to consider some other transition problems faced by students, as discussed in AUT, 1992. There are Academic and Non-academic problems which influence academic performance.

ACADEMIC

The two main problem areas here are: **general** lack of preparedness and **specific** lack of preparedness for tertiary study. The **general** factors include: a student's level of general intellectual ability; discrepancy between the perceptions a student has of tertiary study; and what is expected by tertiary institutions (e.g. rote learning, as opposed to analytical and conceptual thought); limited general knowledge; and ineffective study methods and habits. The **specific** factors include: insufficient command in areas such as linguistic ability; insufficient laboratory experience; and insufficient command of terminology in the natural sciences.

NON ACADEMIC

There are numerous factors here, which include: large numbers of first year students; inadequate methods for early identification of problems; unrealistic expectations; and social adaptation problems; financial and transport problems.

To reiterate: South Africa's Black community in general experiences a large number of problems in the transition to tertiary studies (the attrition rate is well documented). Learners are inadequately prepared for tertiary studies. The urgency of addressing the problems of past disadvantage has increased. Many potential students have left the formal school system prior to Std 10. Those learners who do qualify for tertiary education have little chance of success owing to the poor education system from which they originate.

All of the above has caused most universities and technikons to introduce academic support or bridging programmes.

1.5 BRIDGING PROGRAMMES FOR CHEMICAL TECHNICIANS

This study is concerned with bridging programmes, for which it uses the following definition:

> A bridging programme is a structured teaching arrangement which takes the form of a year of study and /or practical training which is completed before entry to a tertiary curriculum ... In the simplest terms, the need for bridging or academic support arises when a student's school experience is out of phase with the expectations of tertiary teaching (Hunter, 1990:24).

Many students who do not qualify for entrance into National Diploma: Analytical Chemistry (the minimum according to most Technikons is a matriculation pass with Standard Grade D Mathematics and Standard Grade D Physical Science) are enrolled in bridging programmes and follow a programme designed to ensure they cope subsequently with the formal course.

1.5.1 TECHNICIANS

Note that a technician as defined in The Oxford Dictionary is "an expert in the techniques of a particular subject or craft" (compiled by Hawkins, 1988:840). Also, Polanyi wrote "doing science is like practising a craft" (Millar in Wellington, 1989:60). Woolnough writes about a range of practical skills and techniques that scientists have to acquire before becoming masters of their craft (after Woolnough, 1985).

During this study it will be important to keep that description in mind, to avoid being engulfed by arguments that practical work for future scientists is not relevant or worthwhile. It is the training of "technicians" and the Diploma for "chemical technicians" that this dissertation will focus on.

In Kirschener's view "most of the authors, whether social or natural scientists, agree that practicals should be used to teach some general intellectual skills likely to be useful to students in their future work". He continues, by writing that "Teaching laboratory skills through detailed instruction is an admirable way to train technicians, but is of little value in training scientists" (Kirschner, 1992:26).

1.5.2 OTHER INSTITUTIONS' BRIDGING/SUPPORT PROGRAMMES

A pre-university Chemistry course at Witwatersrand University was established to help prospective first-year students overcome transition problems from school to university. The course, with its strong practical emphasis, appears to be "making a significant contribution to improving the quality of student learning and to reducing first year failure rates" (Gerrans et al, 1991:33). Attitudinal surveys and interviews show the general attitude of students towards this course to be favourable. Students commented on the usefulness of the work units and the laboratory periods especially. In addition the practical work was also considered the outstanding feature of the course because it enabled students to work on their own with certain equipment (for most this would be for the first time) and to gain confidence in laboratory work (Gerrans et al, 1991:33).

Another successful programme, the Science Foundation Programme, was launched in 1991 at the University of Natal (Pietermaritzburg campus) to identify academically talented but under-prepared students wishing to pursue a career in science, and to help them to acquire or develop the skills and resources needed to obtain a tertiary qualification in that area. Since a gap exists between the stage students are at and where they need to be, when entering mainstream tertiary education, this programme, too, emphasised practical work since most students from the erstwhile Department of Education and Training (DET) schools had little or no practical experience and, therefore, "lack skills and confidence in the laboratory" (Grayson, 1992:23). No lectures were held formally for the first half of the year. All classes took place in the laboratory as a means of weaning students off rote learning. They would then have to take responsibility for their own learning. The students came to see that knowledge is something that they can build up for themselves through their own experimentation, as opposed to receiving it from a perceived authority. The purpose of using the laboratory to that extent was to make the process of science explicit and to allow students participation. The performance of students was reported by Dr Grayson as encouraging, in terms of both academic success and personal growth.

Ahmed Bawa's address at the Human Sciences Research Council (HSRC) seminar in 1992 stated that the University of Durban Westville (UDW) was yet another institution to introduce a support programme and concluded that science programmes in DET schools were not functioning. The College of Science (situated at the University of the Witwatersrand) was created with the aim of assisting those students adversely affected by the inequalities of the apartheid education system to gain access to tertiary education. Port Elizabeth (PE) Technikon's Pre-Technicians' course also emphasises laboratory and workshop work in order that students learn practical skills and develop creative thinking skills. In 1993 the success rate of the course was stated as the number of Pre-Technician students accepted for mainstream study, expressed as a percentage of the total number of Pre-Technicians in the course. This figure was 58% (Sharwood, 1993:5).

These bridging programmes both enrich and compensate for deficiencies in a student or potential student. Deficiencies in theoretical knowledge as well as in practical abilities are focussed on.

1.5.3 MANGOSUTHU TECHNIKON'S PRE-TECHNICIAN COURSE

Mangosuthu Technikon, catering almost exclusively for Black students, has offered such courses for more than ten years. Its bridging programmes are specific to the various schools of the technikon. The School of Chemistry and Chemical Engineering used to offer a Pre-Technicians' course that included theoretical and practical components. This type of 'discipline' oriented programme, as described in AUT 1992, was directed at students with a disadvantaged school background in Mathematics and Physical Science. The bridging course offered by the School of Chemistry and Chemical Engineering endeavoured to enhance an understanding of basic principles in Mathematics, Physics and Chemistry, develop practical skills to reinforce theoretical concepts in Physics and Chemistry, and improve competence in the use of the English language.

In January 1994, however, the bridging programme was renamed and restructured. It became a general course - **Access Course** - with little practical work incorporated for the Analytical Chemistry and Engineering students. The students were unhappy with the course, as it was separated from the formal courses to such an extent that they felt excluded from the general campus life (lectures were mainly offered after hours and by contract lecturers). This unsuitability resulted in the interest now being shown towards a more integrated curriculum and restructuring for a more suitable bridging/access programme (i.e. one of more practical orientation).

In 1995 the bridging programme reverted to the more practically oriented style, although still very much a separate course from the formal ones and still offered part-time and by contract staff.

1.5.3.1 Practical work in the Pre-Technician Course at Mangosuthu Technikon

It has been clearly indicated that the majority of disadvantaged learners who enrol for Engineering courses at Mangosuthu Technikon have had little or no practical science experience. For such students to achieve even a modicum of success during their study period, it is imperative that practical work be emphasised in their work programme. The practical work integrated into the Pre-Technician Course at Mangosuthu Technikon allows the students to learn certain functions and techniques sequentially and in a structured manner, which provides a firm foundation on which to develop their skills.

Practical work has been a priority in Mangosuthu Technikon's bridging course for chemical technicians. In a poster presentation in 1994, the writer (JT Lafferty) and a colleague (CJ O'Brien) evaluated the bridging course (1989/1990). The findings indicated the success of the bridging course in terms of allowing more students access to tertiary education. The elimination of practical work from the course in 1994 was disappointing for students and appeared to cause problems among them. The end of semester results were poor. Initial findings by the writer, concerning the Access Course, indicated that the lack of practical work was of consequence. Students appeared not to be equipped with the skills required for academic success.

Changes to the curriculum were necessary after the dismal results in 1994. It was the department's viewpoint that an integrated curriculum was needed. The reversion in 1995 to a practically oriented bridging course was welcomed. The problem of contract staff, however, was still around. Contract staff do not have the time or inclination to develop or monitor a course when they are not involved with it completely.

> An integrated curriculum approach allows much freedom in correlating lecture with laboratory (Gillespie et al, 1996:638).

Such a course curriculum would also enhance student employment opportunities and career aspirations. The chemical industry requires students to have had varied learning experiences including practical work, which enable the development of general skills.

The Pre-Technician Course is necessary for under-prepared students entering tertiary education to ensure they will cope with the formal courses like Semester 1 (S1) Chemistry, the first level of the Diplomas in Analytical Chemistry and Chemical Engineering. The acquisition or development of skills and resources is a prerequisite for successful attainment of a tertiary qualification.

1.5.3.2 S1 Chemistry Course related to the Pre-Technician Course

Students who enter the S1 Chemistry course are expected to begin practical work at the prescribed level. The following knowledge and skills are also assumed to have been mastered, for the practical course to continue along the formal curriculum path and be completed within the set time allocated:

*a knowledge of all basic glassware

*to be able to use top loading balances and analytical balances

*to be able to use Bunsen burners safely

*to have knowledge of basic laboratory techniques such as filtration, pipetting and titrating

*to write simple reports

*to be able to observe basic experiments scientifically

*to make simple inferences regarding relevant theory for practical work (expected outcomes of the Mangosuthu Technikon, Pre-Technician Course).

Unfortunately those students entering S1 Chemistry who had been promoted from the Access Course in 1994, had no prior knowledge of some of the glassware. The majority of the students had never used balances or Bunsen burners and could not pipette or titrate. Reports were foreign to them and observations/inferences had never been encouraged as a means to establish proof or to further their knowledge. These facts are probably a result of only theory lectures being supplied. Students trying to enter the formal course without adequate pre-tertiary tuition are, thus, at a disadvantage. The S1 course does not make provision for the supply of the pre-requisite skills. Such skills could have been developed or enhanced in the bridging course.

It is envisaged in the future that these skills should be attained through the school science curriculum. This is clearly documented in the booklet concerning the curriculum framework for Science, Technology and Mathematics (Witwatersrand Centre for Education Policy Development, 1995). Students should gain the skills of scientific investigation by developing intellectual and practical skills. This is necessary in order to explore and investigate the world of science, to develop a fuller understanding of scientific phenomena as well as the nature of the theories explaining these, and the procedures of scientific investigation. Activities such as asking questions, observing, measuring and interpreting results will encourage this process. The problem of the here and now prevails, however. The learning of skills is important to our potential tertiary learners and it is the lack of skills necessary to tertiary education that is proving to be problematic.

Lecturers at Mangosuthu Technikon agreed to answer a short questionnaire, after witnessing the difficulties that S1 Chemistry students and lecturers were facing in respect of inadequate practical tuition. Their responses serve to illustrate the thrust of this section – the importance of a practical component in the course.

1.5.3.2.1 Questionnaire results from S1 Lecturing staff

Five lecturers involved with S1 students were asked to complete a simple questionnaire (see Appendix 6).

QUESTIONS	YES	NO	Easily	Some difficulty	Much difficulty	Not at all
In your opinion was the S1 class competent to begin the formal practical S1 programme? YES/NO * 1 lecturer felt he didn't have enough experience with these groups to give a response	0	4*				
Could the students carry out the first titration without help? YES/NO	0	5				
Did they have any understanding of indicators? YES/NO	1	4				
Did the students recognise the various glassware?			0	3	1	1
Could these students use the top pan balances without assistance?YES/NO	2	3				
QUESTIONS	YES	NO	Easily	Some difficulty	Much difficulty	Not at all

Could these students use the analytical balances without assistance?YES/NO *only after 2 practical sessions	1*	4				
Were pre-prac talks necessary? YES/NO How much time was spent on these talks? Ans: 3@ 10-20mins 2@ 40-60mins	5	0				
Was this (time)different to any of the previous classes taught? YES/NO *2 lecturers were of the opinion that they did not have relevant experience to respond	3*					
Were practicals completed during the specified time? YES/NO	2	3				
Did you ever feel the need to repeat any practicals because students had not gained sufficiently from it? YES/NO	3	2				

QUESTIONS	YES	NO	Easily	Some difficulty	Much difficulty	Not at all
If YES did you repeat a practical? YES/NO *3 lecturers would have preferred to do this but there was insufficient time	2	3*				
Were students enthusiastic to learn? YES/NO	5					
In your opinion, would the practical work normally done during the Pre-Tech programme, have benefited the students? YES/NO	5					
Did the students ever express dissatisfaction with the previous Pre-Technician Course as it had no practical work included? YES/NO If yes could you write some comments (see ** below)	3	2				

** Students would have liked to have learnt the basics about techniques and apparatus.

** General dissatisfaction with the structuring of the course.

** Students felt isolated from the campus body.

How would you rate the practical performance of these students:

Excellent	Good	Fair	Poor
0	1	4	0

It is evident from the answers given by the lecturers involved in this course that the problems students faced were significant. Students from the Access Course were not performing adequately.

1.5.3.3 Performance of students in S1 practicals

The elimination of the chemistry practical work in 1994 was a great disappointment to students for reasons noted earlier. The small group of Access students from 1994 who were promoted to S1 level did not fare well in the practical Chemistry course. They were asked how they were coping with the practical work at S1 level. They responded that 70% coped with some difficulty and 30% with much difficulty. Not one coped easily. Students felt disadvantaged by not having had practical work integrated into their study course: "...when we do practicals it was too difficult because we didn't know what to do. We didn't even know the functions of the glassware and other equipment" **(1994 Access student)**

The students from the previous practically oriented Pre-Technician Course (before 1994), however, answered quite differently: "On reaching S1 from Pre-Tech I was familiar and used to the laboratory work which made work a bit easier" and "The practicals help you right through to the industry" and "As I reached S1 from Pre-Tech I already had a good foundation" **(1989/1990 Pre-Technicians)**

Learning and understanding science involves some grasp of the contents of Science and of the methods of scientific enquiry (after Miller, 1995). Students learn by doing and this is why the Science curricula should emphasise scientific methods of enquiry and include an element of assessed practical work. According to a recent paper concerning practical work in Science, practical work is usually not seen merely as a means towards the end of better content learning; it is also seen as crucial in developing an understanding of the procedures of scientific enquiry (after Lubben and Millar 1995).

"Our lives are the result of natural and synthetic chemistry. A course ought to be organised according to practical applications" (Beall, 1996:641). Such a statement reiterates the importance of practical work in the Chemistry course. Disadvantaged students, as a result of their meagre lifestyles, have little experience of natural or synthetic chemistry and in particular are unaware of its relevance to, or influence on, daily living. Simple practical applications in a Chemistry course would assist in their learning. Further to this it is written that "we should be emphasising to students that scientific theories and principles are based first and foremost on experiment" (Gillespie et al, 1996:638). This would ensure the validation of certain concepts learnt.

Practical work as a component of the bridging course has a role to play in the training of disadvantaged students. It has been indicated that practical laboratory work is desired by the students and thought to be of necessity by the staff. Such positive attitudes towards practical work appear to enhance the learning process.

1.5.4 NOTABLE FEATURES OF SOUTH AFRICAN TECHNIKON PRE-TECHNICIAN COURSES

A full report on the technikons contacted is available from the writer and is also contained in JT Lafferty, COTIL Report, 1995. The COTIL report is overviewed in Chapter Seven, as the writer feels it to be important feeder-information for this study.

The writer was also involved in organising and taking part in a "Workshop On The Future Role Of Access Courses At Technikons" (August, 1995). The participants at this workshop included representatives from seven technikons, two universities, one technical college, two NGOs, one company and a representative from a college in England. Some interesting pointers were discussed and debated which are also included in this section. The following negative and positive aspects are examples of such pointers and were drawn for COTIL (see above).

Negative aspects of bridging courses

* Funding for bridging programmes has generally been from outside donor agencies. The majority of the funding ceased in 1996. Most of the institutions have found this extra bridging course (which receives no subsidy from the state) an extra burden on an already critical financial situation. Generally, no future plans exist for these programmes (some of the various technikons have mentioned a move by higher authorities to locate these bridging programmes within the technical colleges otherwise they might have to cease).

* No common selection criteria exist. Selection, although practised by most technikons in South Africa, is not very effective. It would appear that a more in-depth selection procedure needs to be put into place. Selection by matriculation grades or a points system is not sufficient because of the current status of education in the disadvantaged communities.

* Little or no evaluation as to the effectiveness of these programmes has been done.

* No plans exist to accommodate/ recognise credit bearing subjects and there is no uniformity as to which subjects should be credit bearing.

* In the main, no qualification/certificate is obtained by the majority on completion of the bridging course. If failure results it is a waste of students' and institutions' resources.

* Bridging course staff are generally non-permanent appointments, which leads to little or no ongoing development of course material taking place.

* The duration of the course is generally six months. It is debatable whether a student is able to develop sufficiently in only a 12-week period.

Positive aspects of bridging courses

* Chemistry practical work is encouraged in the majority of institutes. Most practicals are tutored by enthusiastic and dedicated staff.

* Collaborative work (small groups of students studying together and including peer interaction) is being encouraged at some institutes.

* Technikon Northern Gauteng supports this type of programme and uses permanent staff for tuition. Reassessment of practical work is ongoing and contact with industry is active. TNG also has a novel approach to the Physics course, integrating theory with practical sessions for the Physics course. Pretoria Technikon is also involved in updating practical work for this programme and has active contact with industry.

* Port Elizabeth Technikon is one technikon to have evaluated its programme and claims proven success. (If true, that is due probably to its dedicated staff, peer group interaction and incorporation of Pre-Technician students into normal campus life).

* Border Technikon claims to have shown some success, which it attributes not only to dedicated staff but to the fact that students receive a certificate on successful completion of the course.

* UOFS and OFS Technikon together have a most successful programme and the cooperation between the university, technikon, colleges, community and local government is exemplary. Another University concentrating on assistance for educationally disadvantaged students is the University of Cape Town. The University of Cape Town offers in the first year of the Engineering degree a Practical Engineering component which is novel. It is a project-based course involving 36 projects throughout the programme. Two projects are attempted each week. Tasks are set, information given out and resources suggested. Students then need to follow this up with reading and preparation work prior to the laboratory session. This project makes use of engineering design, problem solving and communication skills and also developes manual skills.

In conclusion all groups were affirmative that the need for a co-ordinated effort is apparent. Recurriculation for learners is necessary. Accreditation to allow mobility is required and that flexibility must be built into the courses. In addition the knowledge base among all courses should have some sort of commonality (Access to Technikon Study, Mangosuthu Technikon, 1995:28).

15.4.1 Some features of Technical Colleges in South Africa relevant to practical laboratory work. (See Appendix 7 for a list of Technical Colleges contacted)

* Permanent staff are employed on their programmes

* Little or no practical work is done, owing to a lack of facilities (Umlazi Technical College students studying chemistry at the college have attended practical laboratory

workshops held at Mangosuthu Technikon laboratories)

1.5.4.2 Some features of Non Government Organisations' Bridging Courses

(See Appendix 8 for a list of NGOs contacted)

* Practical laboratory work is emphasised in the majority of these programmes. If facilities for practical laboratory work are not available within the organisation then contact has been made with obliging institutes like Science Education Project (SEP), Programme for Revision in Science and Mathematics (PRISM) and Programme for Technological careers (PROTEC) with the view of utilising their laboratory facilities.

* NGOs have committed staff carrying out the work, with encouraging results being claimed, but often their activities are not competently coordinated leading to inefficient delivery of their activities.

* The Science Foundation Programme locates its science tuition in the laboratory for the first semester of the programme.

* Many NGOs have a rather ad hoc way of operating. Their philosophies or aims are "undeveloped" (Building The Base, May 1993:41) and thus cannot claim to be completely effective.

1.6 DEMANDS FROM GOVERNMENT

South Africa expects an increase in student numbers at all tertiary institutions. This is a reality. The likely success rate of such students however is a grave concern, which will have far-reaching implications. The percentage of white graduates in the science, engineering and technology fields far outweighs the percentage of black graduates in the same field. In 1993 the per capita ratio of white to black undergraduate engineering students was 67:1 (Green Paper on Science and Technology, 1996:72). South Africa is emerging from an era in which the disparities between rich and poor resulted in imbalances in all facets of life. Not least the fields of science and technology require a concerted national initiative to redress these imbalances.

Where necessary, all programmes that are introduced to cope with problems of disadvantage, need to be monitored and adjusted. Higher education institutions will be required to develop strategies to increase not only access to science, engineering and technology (SET) study programmes but to improve graduation rates in those areas as well. Academic support for disadvantaged learners is emphasised in all tertiary bridging programmes. Other facets of education need to be looked at as well to ensure an holistic education for the potential learners.

The Green Paper on Science and Technology emphasises the need for education and training in the science, engineering and technology fields, and recognising the strong practical component necessary for success is essential for improving the quality of life of all South Africans.

The recent formulation of the National Qualifications Framework Bill indicates government's policy of focussing on principles to underpin the future national learning system of which life-long learning will be the cornerstone.

The White Paper on Education and Training describes the overarching goal of the national education and training policy as to enable all individuals to value, to have access to, and succeed in lifelong education and training of good quality (Green Paper, 1996:83).

The integration of academic and vocational skills will ensure that learning activities have competency based outcomes.

This study concerns the training of chemical technicians. It is well documented that more technologists, engineers and technicians need to be trained to meet the growing technological challenges of the times. There will be a shortage of "approximately 200 000 technicians by the year 2000" (Lamprecht, 1992:72)

The shortage of students, in particular Black students, studying Physical Science, Mathematics, and Technical Drawing is a concern. Students who do study these subjects tend to originate from a disadvantaged background , ill preparing them for the demands of tertiary education, as has been shown above. Their practical skills are deficient and their creative skills under-developed. The purpose of a bridging programme should be to administer to those needs to ensure that more students have access to tertiary education. "The technikons could be crucial centres of research and teaching because they generate human resources with a high practical orientation" (Green Paper, 1996:72).

1.7 CONCLUSION

Faced with a demand for improved, active and relevant tuition for the learners of our country, and in order to meet the demands of the economic structures of the land, it is imperative that tertiary institutions take cognizance of, and attempt to redress, the imbalances of the past. It has been argued that the practical skills of many learners facing a future in the science and technology fields are deficient and have proved a problem for higher education. Science is a practical subject and, therefore, contact with real life situations and hands-on experience are essential.

It has been argued elsewhere that, while formalised laboratory practical work may not be the most effective way of learning about science in developed country classrooms, it maybe a much more important site of activity and learning in underdeveloped communities where the school is one of the few modern sector institutions with which students have contact (Kahn, 1993:19).

Bridging courses established at South Africa's technikons to date aim to correct this situation. This study investigates the relationship between exposure to practical work in a bridging course and the success of learners at the bridging course level and as they continue with their tertiary studies.

CHAPTER TWO

IMPORTANCE OF THIS STUDY

2.1 CONTEXT OF THE STUDY

Potential students for the Mangosuthu Technikon live and attend schools in the urban area of Umlazi. Mangosuthu Technikon is therefore committed to working at alleviating the problems faced by the students of this local community. Community Outreach projects are a priority for the technikon.

Initially (1994) the writer together with SEP (Science Education Project, a local NGO) had made contact with the high schools of Umlazi. (The poor state of practical Science work in disadvantaged secondary schools has been written about in Chapter One). A teacher's workshop was organised by the writer and her work colleagues. With the assistance of the laboratory staff this two-day workshop effectively enabled teachers to obtain hands-on experience with practical tuition and subsequently learn ways of classroom implementation. Questionnaires were then sent out by the writer to the many high schools in Umlazi to assess the needs of the schools in terms of Science practical work and their need to access facilities. Several practical Science workshops for the local high school pupils have since been organised by the writer and her laboratory staff. They have been received by the pupils and teachers alike with much enthusiasm. The writer and her laboratory staff are involved continuously with assisting two on-campus NGOs who make use of the laboratories for their work in upgrading science students. The writer, through continued communication with the secondary school community, has also been involved in Teachers Conferences which enabled the writer to organise a workshop and introduce the concept of 'microchem' kits (to carry out practical experiments on a micro scale thereby assisting those schools who face financial and physical space problems) for practical Science work. Such workshops and time spent with the teachers and pupils only emphasised what the writer knew already about the state of (or rather the absence of) practical Science work in secondary schools

The writer, through her continued interaction with students from the local community and communication with teachers, has learnt much about the needs of disadvantaged students for an adequate bridging course to enable them to access tertiary education successfully.

The President of South Africa issued proclamation No R.6. 1995 for the establishment of the National Commission on Higher Education (Government Gazette, Vol. 356 No 16243, 3rd February, 1995). This National Commission accepted a working vision and definition which included the following: The proposed system of Higher Education will be under pinned by the principles of high quality, life long learning, equity, democracy and efficiency and focuses on the need for life long learning and student upliftment

In the writer's experience, and with reference to the ideals expressed by the National Commission on Higher Education, the following passage is pertinent to this thesis (Lafferty, COTIL Report, 1995).

2.2 HOLISTIC DEVELOPMENT OF STUDENTS

2.2.1 "Out -of - class experiences"

The student does not only learn and develop to his full potential in the classroom or the laboratory but rather the full involvement in campus activities and campus life can contribute to valuable outcomes of the tertiary education. To produce an efficient and competent technician is "more like conceiving and nurturing a baby than building a robot from spare parts" (Woolnough, 1991:185). The student needs to understand that being a technician requires hand and mind to work together. Knowledge and skills, the ability to solve practical problems, and the ability to be involved actively in the whole problem solving process form a part of the student's education. The balance of education according to Woolnough (1991) concerns attitudes, motivation, commitment, self-confidence and satisfaction. It is these "all-embracing" factors which "hold the key to student success and fulfilment in practical science" (Woolnough, 1991:185). The development of a student is an holistic phenomena writes Kuh (1995). The results of his research into out-of-class experiences associated with student learning and personal developments were reported in 1995 (Journal of Education, Vol. 66, No 2 April 1995).

2.2.2 Holistic development

Kuh's research is interesting and informative and the findings could apply anywhere. Curriculum designers should be made aware of such findings to ensure that student development is derived from experiences both in and out the classroom. It is imperative, therefore, that future Pre-Technician Courses include incorporating the student into the full life of the campus. Woolnough quotes Hodgkin (1985), who thought similarly about an holistic education for students, when he writes that "personal commitment and challenge, springing from a supportive and stimulating environment, are essential for personal growth and learning" (in Woolnough, 1991:186). The holistic development of the student cannot occur if he or she is separated from the extracurricular activities of the institution. It has also been reported that participation in extracurricular activities has been a more accurate predictor of workplace competence than grades (after Howard, 1986).

Out-of-class experiences, which include living in a campus residence, extracurricular activities, conversations and active communication and interaction with peers or School/department, SRC, on-campus job, have led to "gains in such areas as social competence, autonomy, confidence, self awareness, and appreciation for human diversity" (Kuh, 1995). Student learning and development is directly affected by these experiences. The technikon must take responsibility for ensuring the student feels integrated into the institution and is able to access resources successfully.

From Kuh's report the category mentioned at least once by the greatest number of students as impacting on learning and development was leadership responsibility (planning/organising/decision making), followed by interaction with peers, academic - related activities, institutional ethos, faculty contacts, work and then travel.

2.2.3 Peers

The report gives a student's view on peer interaction:

> "*I think that out-of-class discussions and smaller group discussions have really helped to .... develop the ideas that I've learned in classes. For the most part we only have an hour or so in class or maybe two hours, and there is a small portion of time where we can throw ideas back and forth and get a discussion going...... So after class - in your room or in the coffee shop - is a really good time to further those ideas and to flesh them out*".

2.2.4 School/Department Contact

Obviously, knowledge and academic skills are gained from contact within the classrooms and laboratories but it is also useful for students to be involved in project or research work with their lecturers. The advantages are not wholly directed towards the narrow confines of their course but lead to independent work as well as to confidence in accessing resources.

2.2.5 Curriculum goals

The designing of curriculum goals should be complemented by out-of- class events (after Kuh, 1995) since, increasingly, job requirements emphasise the ability to communicate, cooperate and exhibit strong interpersonal skills.

2.2.6 Pre-Technician

Unfortunately, the beginning of institutional life for a Mangosuthu Technikon bridging course student divorces him or her from regular campus life. The student is made to feel inferior, is not incorporated into the student body, has little access to resources since lectures are given after regular lecture times, has infrequent access to contract staff (who are paid hourly) and cannot join in social activities planned for after hours. The foundation to the Pre-Technician student's education is therefore not well laid. However, the student is expected to be a fully integrated student at the formal SI level. Despite serving six months outside the system, he or she is expected to take up responsibilities as a mature and focussed young student in the formal courses.

The following findings stem from questionnaires sent out to students who have experienced the Pre-Technician Course and the Access Course at Mangosuthu Technikon.

As an Access student; did you feel a part of the technikon campus life?

"Not that much, most of the time I felt like I had the lowest standard of education in the campus".

"I felt like they used us to pay for the new building they were building because we were so many"

"No, we were excluded they also said that the access was not run by the technikon "

The following is a numerical result from a questionnaire given to the Pre-Technician students attending the first Semester 1995 (School of Chemistry and Chemical Engineering)

As a Pre-Technician student, did you feel a part of the technikon campus life?

YES	NO	UNSURE	DID NOT ANSWER
64	31	1	10

2.2.7 Participation

To ensure an ethos where holistic development of the student is valued, it is imperative that the student enjoys participation in all aspects of institutional life from the very beginning.

2.2.8 CONCLUSION

An integrated bridging course is needed for the holistic development of a student. It is to be hoped that the many problems faced by educationally disadvantaged students attempting to access tertiary education will be minimised and that, once accessed, tertiary education will be successfully pursued.

2.3 PRACTICAL LABORATORY WORK AS TRAINING

Practical laboratory work as training for a chemical technician is perceived as a matter of importance by all persons contacted for this dissertation. Practical work is deemed necessary by the community, the students, the staffs of the institutions, the institutions and by the industry which the institutions rely on to under-take the further training of their technicians. The previous chapter stated that practical work for potential chemical technicians cannot be stressed enough. Practical work in the bridging courses is particularly important to disadvantaged students as it is at that particular level that he/or she will be introduced to such a mode of tuition probably for the first time. Bridging course practical work will lay the foundation for the formal course work to follow.

Schematic learning (the organisation of past actions which then become the seed bed for interpretation and future learning) is a type of learning which could be promoted by laboratory work. It is the writer's experience that a student will make use of practical laboratory work to assist in moving from familiar frameworks to unfamiliar knowledge. Laboratory work lays the foundations on which to build relevant concepts, and also consolidates prior learning ultimately acting as the launching pad for further knowledge acquisition.

It is the active involvement of students during practical sessions which as Piaget suggests lays down the schemata for future learning. "An active, experience seeking child is prominent in Piaget's theory of cognitive growth" (Child, 1993:50). This learning by discovery should, it is hoped by teachers, "produce problem solving skills, especially those involving inductive reasoning" (Child, 1993:106). Practical laboratory work also obeys the principle of exploration and discovery. This form of learning is directly opposed to the narrative method of telling — a type of tuition our educationally disadvantaged students have been heir to. Slabbert (1994) writes that "learning is a process of constructing meaning through discovery. Galileo said that you cannot teach someone something; you can only help her to discover it by herself (Buscaglia, 1986:176)" (in South African Journal of Higher Education, Vol. 8 No 1,1994:39).

Laboratory work also obeys the principle of experiencing: "experiences inhibit or incite a person's involvement in every attribution of meaning. In the teaching-learning situation, where the teacher makes use of the pupils' experiential background and continuously seeks to provide new experiences for his pupils, educative teaching and learning will take place effectively" (Piek & Mahlangu, 1990:36).

A learner learns through exploration; "he experiences and learns by observing concrete things" (Piek & Mahlangu, 1990:44). Piek and Mahlangu continue that abstract thinking will be based on a learner's experiences or on his concrete knowledge. Practical laboratory work with experiments will "pave the way for more abstract thinking by the pupils"(Piek and Mahlangu, 1990:44). Exploratory learning also integrates all forms of learning — rearranging, reorganising, analysing, synthesising — which hopefully finally leads to understanding.

From some of the literature which is mentioned above there appears to be a preference for learning by inquiry, which has as its main purpose "to develop in pupils the ability to learn on their own" (Piek & Mahlangu, 1990:185).

Practical work serves many purposes within the limited curriculum of the bridging course. Firstly, it firstly allows the students to experience first hand (and for many for the first time) some experiments which consolidate knowledge acquired during their schooling. Secondly, it serves to induce further interest in students with regard to the subjects they are studying. Lastly, it integrates all the forms of learning mentioned above and gives students the confidence to continue exploring. This integrative mode of learning will bring about satisfaction and confidence in the learner as he and/or she prepares for the formal course and the eventual formal qualification of the National Diploma: Analytical Chemistry. It is likely to produce able and responsible chemical technicians to serve the economic needs of South Africa.

The writer has established that bridging courses impact on formal courses and, as a result, the courses will need to change not only format but content as well. Bridging courses appear to be set to stay for some time yet but the dynamic nature of these courses demands the same of the formal courses. Bridging courses cannot stay out in the cold forever. Bridging courses will need to be given formal accreditation in whatever manner the authorities deem worthwhile. The continuing changes in South Africa need to incorporate an equally flexible tertiary education system.

To conclude, "The separation of educationally disadvantaged students from the mainstream and subjecting them to 'special' programmes is increasingly being met with severe criticism. It is argued that disadvantaged students are in this way being restrained from the quality education of the mainstream students and it is suggested by Slabbert (1994) that the special needs of disadvantaged students should be provided for in ordinary learning situations. (in South African Journal of Higher Education, Vol. 8 No 1, 1994:39).

2.4 THE ROLE OF INDUSTRY IN TRAINING

Section 6.2 in Chapter Six deals with industry's demand for practical training of future technicians. Lindeque (1993) stressed the need for technikons as educators to "enter the world of the employer and the employee in the work situation" and to take a "leading role in developing an integrated approach to education and training in South Africa" (Lindeque, 1993:6). The writer established, from questionnaires sent out to representatives in industrial companies, that the areas student technicians are least skilled in are: quality assurance, time management, instrumentation and industrial laboratory knowledge. (See Chapter 6). When the writer approached the respondents in industry regarding the areas of course study that should be emphasised, the majority requested that a greater emphasis be placed on instrumentation and applications (which would include practicals relevant to industrial work) and on relating theoretical knowledge to practical applications and the understanding of techniques used in wet chemistry. Industry did, however, acknowledge however that the general nature of the chemical technician's diploma makes it difficult to include the focus on specific industrial knowledge. During interviews with various industrial representatives, it was concluded by the writer that industry desired input into the practical tuition of technicians. This area needs attention by the curriculum developers as little input from industry is noted in the chemical technician courses on offer at technikons. The representatives also mentioned that experiential trainees lacked the ability to communicate competently, and lacked computer skills as well as relevant industrial knowledge. It was proposed that project work which related to industry should be introduced into the technician's courses. (See Chapter 6). The common demands from industry concerning students' inadequate communication skills led the writer to include a report (see 2.4.1.1) in this section (Lafferty, COTIL Report, 1995).

2.4.1 LANGUAGE

Kahn (1993) gets to the heart of the matter when he writes that, "The use of a second language as medium of instruction for the sciences is an acknowledged problem throughout Africa" (in Building the Base, May 1993:49). Since there appears to be no clear divide between language and the process of acquiring knowledge, most tertiary institutions have given priority to developing language skills.

The use of words both in textbooks and by teachers, results in the misunderstanding of scientific concepts writes Jiya (1993). "The interpretation of scientific phrases and concept-words have, potentially, a great influence on the conceptual learning of students, especially those who are taught in English and come from a school background which is disadvantaged educationally. Verbal comprehension is an important determinant in the cognitive process" (in South African Journal of Higher Education, Vol. 7 No 1, 1993:80). It is documented that words which cause problems in conceptualising scientific ideas are not merely technical jargon but are words which occur in normal daily English usage. The above problems serve to emphasise the necessity for tertiary institutions to ensure academic support is offered to alleviate such problems.

2.4.1.1 REPORT FROM SAAAD WORKSHOP (1995): LANGUAGE IN CURRICULUM

The following facts concerning Academic Development / Academic Support Programmes at various tertiary institutions within Kwa-Zulu Natal were noted at a Language in Curriculum Workshop (SAAAD May 1995).

*mainly contract staff are employed in the area of Academic Development Programmes (ADP)/Academic Support Programmes(ASP)

*there appears to be no clear working definition of AD/ASP/ESOL(English for Speakers of another Language)

*teaching locations are removed from the formal course settings

*funds normally originate from outside the institution

*there is minimal leadership or institutional impact from this area

*the ADP courses are not incorporated into mainstream courses

*language is separate to actual content of, for example, English courses

*the focus is mainly on first year students - 'to bring them up to speed'

*language is poorly conceptualised within and between departments and institutions

*most language courses were not credit bearing

Such facts are not strengthening the position of ADPs or ASPs but are, rather, seen as factors detrimental to the learning programmes of students. All students need academic development, which is not peculiar to disadvantaged black South African students but is the case throughout the world. The consensus is that tertiary institutions should take responsibility to ensure ADP/ESP exists and that the needs for a more integrated approach become priorities.

2.4.2 THE NEED FOR CHANGE

There is a need for ADPs or Departments of Communications at technikons to undergo change. They tend to be seen as quick fix centres and not as integral parts of the students' course programmes.

The present scenario must be avoided in future planning. At present:

*language is kept separate from the syllabus, not seen as part of an holistic teaching and learning environment

*language courses appear to be product driven as opposed to process driven (i.e. the language and/or communications curricula demands that the English language be mastered so the lecturer aims to do that regardless of the manner in which it is achieved). In such product driven courses there is a perception that a lack of sensitivity towards the learner and his or her learning problems exist.

*time is always a factor (i.e the quantity to be taught is the priority, rather than the quality).

*the curricula or contents of subjects are of secondary importance to the enforcement of correct language use

*preferred language usage follows the dictates of middle-class, mother-tongue diction only, rather than other forms that students could become involved with and make use of

*students' perceptions of language are adopted from the lecturer and if the lecturer has a rather intolerant approach then a negative perception of the language could persist ...

In addition to the above, the following assumptions suggest themselves from the structures of present language courses.

*White middle class students have the necessary background knowledge to cope adequately with tertiary education courses.

*The disadvantaged learner will never be competent in that language; what a student can't write he can't understand.

*Only language stands in the way of progress.

These negative factors and attitudes have to be addressed and it is with this in mind that the resultant recommendations are suggested:

2.4.3 CONCLUSION

Multicultural students bring with them varying background knowledge and idiosyncrasies to which the lecturer is not always sensitive. It is important to note, then, that one must value the experiences of others when determining their linguistic competencies and background knowledge. Language is the vehicle by which one communicates a subject. One needs to ensure that students develop the tools to cope with this. Usage of language should be continually negotiated with students, whose backgrounds are an important consideration. Teaching should be related to real life experiences, especially when competence in a particular language cannot be relied upon. This will allow one to understand that knowledge is created and gains meaning as a consequence of experience and social interaction.

The Science Foundation Programme at the University of Cape Town has reported that separate language development courses "have generally not proved to be effective, so language development programmes are instead being provided as integral components of certain core courses such as Physics and Chemistry" (The Science Foundation Programme, UCT, 1995).

An example of this occurs in the UCT Physics department where laboratory reports have become part of language and communication skills exercises. In the Engineering I course there also exists Introduction to Studying Engineering. This is an activity based component of the course. Students are introduced to the demands of their Faculty, are helped to understand their Engineering curriculum and so prepare for a career in Engineering. The students are set group and individual tasks for which submissions are required. Reading and tasks are also set for students to work on prior to each session. Assessment is based on all assignment work submitted. A 100% attendance and good results for assignment work are necessary to pass.

South African researchers and workers in the academic support fields are doing much to correct the imbalances in tertiary education. In particular the area of language and communication is being targeted. Choice of content, level and appropriate language tasks are enriched as a result of joint consultations. These are the findings reported by Kotecha and Rutherford (South African Journal of Higher Education, Vol. 5, No 2, 1991). They advocate team teaching by linguists and subject specialists to ensure collaborative teaching of Science/Engineering students in the area of language and communication. The chances of using 'relevant, accurate and informed materials' are increased and a 'greater sharing and ownership of languages is created'.

The practical courses for chemical technicians at technikons need to take cognizance of the above factors with which industry is concerned. Courses should focus on the demands of industry, to ensure that students satisfy their employers.

CHAPTER THREE

LITERATURE SURVEY

3

3.1 INTRODUCTION

Throughout a literature search, one encounters many viewpoints. These range from a positive attitude that "student laboratory work has been regarded as an essential step in the socialisation of students into the state of scientific literacy, or even into professional science"(Hegarty-Hazel, 1990:3) to a strongly negative attitude of "Who needs laboratories?" (Richmond, 1979:349).

It will be seen in this chapter just how diverse are the attitudes towards, and comments on, the importance of laboratory work. The important factor to keep in mind is that many of the potential chemical technicians training at technikons in South Africa hail from decidedly different backgrounds than do those outside the country and, more specifically, outside the continent of Africa (See Chapter One). This survey of pertinent literature will apply itself to the Pre-Technician Courses which have been, and are being, offered at Mangosuthu Technikon.

3.1.1 AIMS AND APPROACHES OF PRACTICAL WORK

> ...students are engaged in learning the basic subject matter of a field which scientists learned in their student days plus the way in which scientists practise. If students are ever to discover scientifically, then they must first learn both the content as well as how to discover!" (Kirchner, 1992:36).

Woolnough and Allsop, proponents of the belief that ties between practical work and theory must be severed, claim:

> Tight coupling of practical and theory can have a detrimental effect both on the quality of prac work done and on the theoretical understanding gained by the students (Woolnough and Allsop, 1985:43).

They also identify three fundamental aims which justify the use of practical work:

*developing practical scientific skills and techniques

*being a problem-solving scientist

*getting a 'feel for phenomena' (Woolnough, 1985:43)

The skills Woolnough lists as those that need to be developed are observation, measurement, estimation and manipulation. Pella from the University of Wisconsin writes about the following objectives related to laboratory activities:

*securing information

*determining cause and effect relationships

*verifying certain factors or phenomena

*applying what is known

*developing skill

*means of providing drill

*helping students learn to use scientific methods of solving problems

*a means of carrying on individual research (Pella, 1961:29)

Millar and Lubben write that it is the exposure to the increasing experiences of the above types of activity that enable the learner to improve his or her ability to carry out scientific investigations (after Millar and Lubben, 1995). Melanie Cooper states that studies have revealed "that as students become more personally involved in their learning, they are more likely to graduate" and that active involvement is "especially critical" for "disadvantaged minorities" (Cooper, 1995:162).

Moreira sees little interdependency between theory and experimentation, and questions how laboratory instruction contributes to the understanding of knowledge production in science. He does, however, concede that those goals may not be suited to an introductory course. He states that, at such levels,

> laboratory instruction should be designed to provide concrete examples and demonstrations or to develop skills such as measurement skills. Perhaps laboratory instruction should have an end in itself and not be seen as a means to facilitate the learning of subject-matter concepts, principles, laws and theories (Moreira, 1980:447).

Tamir defines a laboratory "as a place where science students are engaged in 'hands-on' activities such as observations and experiments" and continues that "its major uniqueness lies in providing students with opportunities to engage themselves in the process of investigation and inquiry"(Tamir, 1977:311). Ben-Zvi et al investigated the relationship between laboratory mode of instruction and other modes of learning in high school Chemistry. Their findings showed that "the practical domain can be sub-divided into three distinct modes: problem-solving ability, skills in the performance of routine laboratory tasks, and the ability to make observations" (Ben-Zvi et al, 1977:433). Garnett and O'Loughlin, write about laboratory work as contributing to the development of a range of process and manipulative skills. Their list of objectives is extensive and is divided into four categories, namely: planning, experimenting, analysing and interpreting observations and data, and finally drawing conclusions. The focus of their paper is on another problematic area -- assessment of practical work -- but it points out the importance of mastering the various process and manipulative skills (Garnett and O'Loughlin, 1989:27).

Millar and Lubben (1995) wrote a paper focussing on understanding the methods and procedures of enquiry used in science. They emphasise the importance of teaching students something about the nature of scientific enquiry. Students, hopefully, will then come to understand scientific accounts (after Millar and Lubben, 1995). Giddings and Hofstein see the major role of the laboratory as being "to provide students with the opportunity to engage in processes of investigation and inquiry" (Giddings & Hofstein, 1980:57). They identify the skills associated with laboratory work as Jeffrey's (1967) six areas:

* Communication
* Observation
* Investigation
* Reporting
* Manipulation
* Discipline (maintenance of order and observance of safety procedures), (Giddings and Hofstein, 1980:57)

White confirms his belief that a syllabus concentrating on the 'things' (White, 1988:160) chemists do such as analysing, synthesizing, purifying, studying structures, searching out properties and controlling reactions would involve the student in learning chemistry through practical exercise. His model of learning, however, suggests that the laboratory should not only provide training in motor skills but should also be a source of episodes that form attitudes, make propositions meaningful and develop cognitive strategies useful in learning and problem solving. The laboratory experiments should include a few experiments unusual enough to establish specific episodes to which important knowledge can be linked. White's ideas are refreshing. It is the writer's observation that students whose backgrounds have been dour and unmotivating are fascinated by the unusual and relate to such events positively. A teacher or tutor can make classroom tuition more effective by linking such episodes to theory.

Many writers suggest similar aims and objectives for practical work; these are well documented. It remains to apply the findings of this literature survey to the practical component of the Chemistry course for bridging technicians at Mangosuthu Technikon.

3.2 THE LACK OF PRACTICAL WORK DURING SECONDARY SCHOOLING

The aims of the South African Standards 9 and 10 Physical Science syllabuses are to provide pupils with scientific knowledge and appropriate technology, as well as to train pupils in the skills necessary to observe, measure and apply scientific principles . In addition there is the need to cultivate both an eagerness to learn and a scientific attitude towards the relationship between scientific principles and the world of industry. Unfortunately, a great number of teachers "lack the knowledge" (Fish & Crossland, 1995: 1), confidence and facilities to achieve those aims. Very little if any practical work is done prior to tertiary study with the consequence that basic skills are not learnt and "too few pupils leave school with these attributes" (Fish & Crossland,1995:1). A positive attitude towards Science as a popular subject and a sense of the necessity for technology are lacking. The emphasis on content at the expense of process is a concern which the bridging course must address.

Mangosuthu Technikon realised the need for change or rearrangement to formal courses, to allow greater access to technikon study by the disadvantaged learner. A bridging programme for engineers and technicians was implemented more than ten years ago. The bridging programme for chemical technicians at Mangosuthu Technikon is a programme attempting to prepare students for the National Diploma: Analytical Chemistry or National Diploma: Chemical Engineering. The bridging course attempts to expose students to the industrial fields of chemistry and chemical engineering. Such a course, therefore, demands the combination of theory and practice.

Professor Hills (1992) of the University of Strathclyde confirms the thoughts of many concerning the linking of theory and practical work when he writes: "If ever there was a subject demanding practical skills it is chemistry. Part of its charm, and the satisfaction of being a chemist, is that so often it springs surprises undreamt of by theory" (Hills, 1992:28).

The loss of potential students and valuable resources as well as the high costs attached to unsuccessful study (which is a source of concern to the State) must be rectified. Bridging programmes are a mechanism designed to do just that.

> In the simplest terms, the need for bridging or academic support arises when a student's school experience is out of phase with the expectations of tertiary teaching (Hunter, 1990:24).

The student body peculiar to Mangosuthu Technikon needs to be carefully considered prior to investigating courses studied at the technikon. Typical courses for Chemistry and Engineering in South Africa have a form and structure that articulate most successfully with the schooling of white, mainly male matriculants. This is in contrast to the composition of the predominantly black male student body of Mangosuthu Technikon. Formal courses at tertiary institutions demand subject-specific knowledge, computer literacy and experience of technology. Jawitz (1993) recognized the hazards of such a format when he wrote, "A challenge facing Engineering and Science faculties is to begin rearranging courses to eliminate these assumptions about familiarity with technology and to include learning activities that expose students to as much of the phenomena of science and engineering as is possible" (Jawitz, 1993:2).

Practical laboratory work is a new concept for the majority of black students originating from typical "township" schooling. Chapter One has clearly shown the limitations and problems of the schooling that the majority of Mangosuthu Technikon students have experienced. The students have had little or no exposure to practical work and the same applies to demonstrations.

As described in Chapter One, a questionnaire was administered to students in the first semester 1995 Pre-Technician Course. A similar questionnaire was given to students in the first level of the formal Chemistry course (S1) in 1995 (see Appendix 5) and then again a similar questionnaire to Pre-Technician students in the first semester 1996 (see Appendix 9). The student questionnaire circulated by the writer to technikons in 1997 also garnered some interesting facts.

To summarise and reiterate from Chapter One, 51% of the 1995 Pre-Technicians answered that they had had no practical facilities at their schools (after Lafferty, 1995). 63% of the S1 students who were questioned answered that they had not had the privilege of hands-on experience in the Chemistry class. 60% of those S1 students also responded that only demonstrations were available to them.

Of the 1996 Pre-Technicians a slightly higher percentage (57%) of students had been able to carry out hands-on experiments at school. The responses from the 1997 students were similar to those determined in 1996. Only 16 of the 30 questioned had had practical facilities at their schools to allow for Physical Science experiments (i.e. 57%), while 14 had had no such facilities. Of the 16 who had had facilities only 1 acknowledged being able to do the experiments as an individual, 5 had worked in groups and the balance relied on teacher demonstration only. Once again the majority of students were faced with the disadvantage of limited practical experience when entering tertiary education.

The following comments received from various formal or Pre-Technician students, about their practical experiences during secondary schooling once again emphasise the dismal background from which a majority of our students come.

> *"I didn't receive any experimental work training because there was nothing left in the laboratory"* **(1994 Access student)**

> *"the laboratory was changed to a classroom because there was a shortage of classrooms"* **(1994 Access student)**

> *".....most of the things which were needed for learning were not sufficient at our school eg chalk, mathematical instruments, damaged blackboards, holes in the roofing, dirty toilets...."* **(1994 Access student)**

> *"There was a laboratory but we didn't go there much because there was not enough apparatus and chemicals"* **(1994 Access student)**

> *"There were no laboratories so there were no pracs - our teachers didn't even bother to ask the near by schools to assist us"* **(1994 Access student)**

3.3 THE DESIRE FOR PRACTICAL WORK

Excitement, and a subsequent motivation to study science, gained by seeing chemistry "live", was exhibited by the Pre-Technicians. The following comment from a student emphasises this point... *because when doing practicals you actually see what is going on, not just told a story. So in that way (one) easily remembers, that I have done this and that, if a question is asked in a test or examination* **(1994 Access student)**

It is also a general perception that chemists choose to study Chemistry as a result of fond recollections of the magic of chemistry learnt at school, which includes growing beautiful crystals, the odd exciting explosion and, of course, colourful reactions (Education in Chemistry, 1993:2). The excitement of seeing chemistry live, which motivates students to seek further knowledge, was, as mentioned above, removed from the Pre-Technicians' Course. Theory and practical work in the Pre-Technicians' Course became separate issues and no relationship existed between the two. Millar et al (1995) believe that for successful learning to take place a students must be able to "transfer understandings from one context to another" and since the 1994 course did not allow that to take place there was also no possibility of improving learning by "better structuring and sequencing of experiences" (Research papers in Education, Vol 9, 1995:209). "Laboratory experiences will serve to develop and or strengthen higher order thinking - an essential skill" (Sutman and Scmuckler 1995:183) if students are allowed to practice science as it is in the 'real world'.

> Learning is not the simple absorption of knowledge but the construction of meaning through the individual's relating things seen and heard to things already known. Learning is active, not passive (White, 1988:160).

Students, like children, should be assisted to gain independence through practical work and should this independence not be available then it could result in a student being hesitant to explore new learning material as well as new social situations (after Piek and Mahlangu, 1990).

Demonstrations used as a form of practical work should aid in convincing students of the importance of chemistry.

> The result of laboratory instruction should be a more comprehensive view of science including not only the orderliness of its interpretations of nature, but also the tentative nature of its theories and models (Boud, Dunn and Hegarty-Hazel, 1986:5).

Demonstrations and/or practicals provoke thought and entice students to ask questions by stimulating their interest. "When demonstration is a hands-on activity it stimulates student interest effectively" (Beall, 1996:642). Laboratory work (according to Huddle and Bradley) such as that introduced into the bridging programme enables students to move away from being "passive receptors of information" to becoming "participants in the construction of knowledge" (Huddle and Bradley, 1991:73).

The eagerness to learn is very real among Pre-Technician students at Mangosuthu Technikon. This eagerness manifest itself in the practical laboratory when students come face to face with actuality instead of a multitude of words and diagrams. Students enjoy the activity and excitement of practical work. Most students express their desire to be involved with practical work from the outset.

Blair et al support this when writing of the child wishing "to be free to do the things he is capable of" (Blair et al 1956:80). Several other studies indicate the popularity of laboratory work among secondary and tertiary students. One study confirms that a common thread among science students is that "many of them enjoy labwork and prefer it to the other modes of learning"(Gardner and Gauld, 1990:136). Gardner and Gauld make specific reference to the various studies encompassing this perception: Hofstein et al (1976) reported that labwork was more interesting than teacher demonstrations, lectures or filmed information. Gagne and White (1978) postulated that students who are involved in practical work would store in memory an episode relating to this work more readily than if it was demonstrated by a tutor. They further emphasised that practical work would enhance learning and retention of scientific knowledge associated with an experiment. Atkinson and White (1981) also wrote about active involvement in laboratory work being a possible strategy for enhancing student learning and memory of scientific knowledge. In short, the particular researchers mentioned above appear to prefer active involvement to the passive involvement of teacher demonstrations or theoretical information.

3.4 DEVELOPING POSITIVE ATTITUDES TOWARDS PRACTICAL WORK

The attitudes of Mangosuthu Technikon students regarding the practical component of the Pre-Technician Chemistry course (bridging programme) can be seen in the following answers extracted from a questionnaire given to a group of 1995 students (past and present Pre-Technician students) on completion of a semester of study (see Appendix 4). The questions given to this group of Pre-Technician students (present and past) was aimed at the course as a whole but answers pertaining to practical work have been extracted.

What do you think such a bridging programme as Pre-tech Chemistry should achieve?

"A good idea of how things are done in the laboratory."

"A student should get used to the laboratory equipment and to be familiar with the practicals"

"I think it helps a lot because some students didn't know what they were going to do....... In bridging they get a chance to choose."

"....more practical knowledge"

"one should be well prepared for S1 challenges...."

"Bridging course help students to upgrade their knowledge of practical work"

"......that the student should be able to do practicals."

"....achieve the knowledge of how to use some apparatus in the lab."

"Prepares students for the course they would like to do"

"....that they should be able to do practicals"

"to teach a new student to cope with the campus"

"help you get used to practical work"

"helps a person in science practicals because in some other schools they did not have practicals in science."

"Assisting students who were disadvantaged at high school"

"confidence when it comes to practicals"

"preparing students for their actual course"

"...familiar with the course.....what you will be doing in the lab and in the classroom"

"Must introduce each and every student in every resources of his / her course and must have practicals"

> As a chemistry student I think pre-tech classes must be in a way so as to fill the matric gaps eg more practicals must be introduced/plant visits so that students should see the implementation of what we study in the industries (Lafferty,1995:2)

In researching other South African bridging programmes which incorporate a practical component it would appear the enthusiasm for practical work is not limited to Mangosuthu Technikon students. Students participating in the Pre-University Science (P-US) Course at the University of the Witwatersrand had a positive response: an increased (21%) positive perception that laboratory work was valuable was achieved over the year and 64% of the students regarded laboratory work as "valuable" (Bradley et al, 1991:38). In a separate report the positive attitude was corroborated: "The work units and laboratory periods proved especially useful to the students"(Gerrans et al, 1991:38). At Port Elizabeth Technikon (where a most successful Pre-Technician Course is offered to potential technikon students) the majority of students, according to the Dean of the Faculty of Applied Sciences , Mr Derek Sharwood, enjoy working in the laboratory and confirm that the practicals assisted them in understanding the theory (after Sharwood, 1995).

Is enthusiasm sufficient to ensure success when training to be a technician? Practical laboratory work is not only a method of teaching theory. It is also "our pupils' introduction to the reality of experiment with all its qualities of painstaking care, inventiveness and precautions" (Solomon, 1980:129). Potential chemical technicians participating in the Pre-Technician Chemistry course at Mangosuthu Technikon have been deprived of this. They know little of the substance of real science. The processes which a scientist follows in his working life are foreign to the students. Students appear eager to be involved with real, 'hands-on' science and it is this enthusiasm which keeps them interested in the Science course as a whole. It is this writer's observation that students develop a personal interest in the understanding of scientific concepts and the meaning of what is happening,through hands-on experiments. Fowler, in an unpublished paper, posits two Axioms for the laboratory as an educational medium.

> Axiom 1 states that it is in the lab and only in the lab that the student can experience physics as it actually is. Axiom 2 states that for learning to take place effectively, the student must be motivated through interest" (Kirschner,1992:26).

This would then support a motivational rationale. Students enjoy activities and practical work (see above and Chapter One).

In a paper entitled "*The measurement of the Interest in, and Attitudes to, Laboratory Work amongst Israeli High School Chemistry Students*" we are asked to consider the suggestion that "we are entering an era where we will be asked to acknowledge the importance of affect, imagination, intuition and attitudes as outcomes of science instruction as at least important as their cognitive counterparts" (Hofstein et al, 1976:401). The general conclusions of the paper once again stress that interest in, and a positive attitude to, laboratory work play a significant role and should not be neglected. Many students at Mangosuthu Technikon have come from technologically deficient backgrounds and the slightest laboratory exposure is a new and exciting process.

Stephen de Meo also writes about the role of the affective domain in learning Chemistry.

> This latter aspect of the mind is important since chemists do not create in an emotional vacuum; they become excited with discovery, are proud of their work, often are sceptical, and even become frustrated and stubborn at times. In other words chemists' work like others is emotionally laden" (de Meo, 1995:932).

In support of the previous views that learners learn best when interested and motivated, the first and only Briton into space, Helen Sharman, said, "What better way of enthusing children to science, than to show them how we use science" (Education in Chemistry, 1993:2). Driver et al (1994), reiterates yet another author's view that making science plausible to students in the context of a memorable experience enhances the learning experience through practical work.

In support of the above Kirchner (1992) writes that it is recognised now that various instructional strategies are needed to promote the learning of different types of scientific knowledge. Christophi and Davies (1992) add to this when writing that "it is generally accepted that providing students with a wide variety of learning styles makes good educational sense. Not only is variety of approach refreshing and motivating for students but, from a cognitive view, different children learn better in different ways" (Christophi and Davies, 1992:14). In science we, as educators can employ a variety of teaching methods, which should include problem-solving, fieldwork, library research, art work, discussion and practical experimentation.

3.5 THE INFLUENCE OF PRACTICAL WORK ON COURSE WORK

From the turn of the century a move was initiated away from the emphasis of school Science on learning facts and concepts, towards a discovery approach. In 1998 practical laboratory work is still considered an integral part of the Science course but the arguments as to its appropriateness and effectiveness have long been waged. Whereas before, a laboratory was used not only to verify facts or concepts but also to discover, it is now increasingly being asked that such work enable students to "engage themselves in the process of investigation and inquiry" (Pinchas Tamir, 1977:311). Tamir argues that if laboratory work is to be considered effective learning then the question of whether or not the curiosity level of the laboratory increases as students move up the educational ladder should also be considered.

"Science educators are increasingly seeking to understand how laboratory experiments actually influence the learning of scientific knowledge" (Kirschner, 1992:17). This sentiment is echoed by Shulman and Tamir (1973): "The research on the relations between laboratory and other learning modes remains scarce" (in Ben-Zvi et al, 1977:43).

There is much written in recent literature about laboratory work's achieving its objectives. Joan Solomon (1988) begins her paper with an introduction praising Millar and Driver(1987) and Woolnough (1985) for casting doubt on "the equating of learning science with practising its experimental skills" (in Solomon, 1988:103).

Millar argues that although the 'process science' approach to teaching (as opposed to the 'content' approach) is popular since it seeks to involve students more actively in science, the flaw is "that it confuses means and ends - it fails to see that active learning approaches are the means of engaging pupils' attention and interest in science lessons, but are not themselves the ends or goals of instruction" (Millar, 1989:58). He continues that a way forward would be to identify and separate specific skills, which could be taught and improved and assessed, from more general processes, which cannot. The aim of school Science should be to develop and promote attainable goals such as "scientific observing" and "scientific hypothesizing". This would ensure, he claims, that students are helped to internalize the procedures and standards of the scientific community.

> But what is this practical work for, and what learning does it promote (Millar in Woolnough, 1990:43).

When trying to answer the above question, Millar (1990) discusses the identification of the two rationales for practical work, namely: facilitating the learning and understanding of science concepts and developing competence in the skills and procedures of scientific inquiry.

The many proponents of the need for science to be "process-led" rather than "content-led" claim that general skills can be taught and then transferred from the context in which they are learnt to new contexts and beyond (after Millar, in Woolnough, 1990). Millar argues however that these general cognitive processes cannot be taught and the use of practical work for this is untenable. But, he continues, practical techniques can be taught as can inquiry tactics. (See table below)

Practical skills

General cognitive processes	Practical techniques	Inquiry tactics
such as.......observe	such as.......measure temp with a thermometer	such as........repeat measurements
.................classify	.................separate a solid and a liquid by filtration	..................draw graph to see trend
.................hypothesise		..................identify variables to alter, measure, control
cannot be taught	can be taught and improved	can be taught and improved

(in Woolnough, 1990:51)

There is much being written, argued and discussed about the effectiveness of practicals. Most writers like Kirschner (1992) agree that practicals are "an essential part of the science curriculum" (Kirschner, 1992:60) and he argues that practicals are the "proper vehicles for the teaching/learning of syntactical structure of the scientific domain" but are "not very useful" as "vehicles for the teaching or learning of the substantive structure of the scientific domain" (Kirschner, 1992:60). Most writers argue that practical work needs to be revisited in terms of its immediate objectives. White (1988) believes that most students perceive lab sessions as isolated events and that lab work may not have a good effect on understanding or problem-solving because it is "inappropriate laboratory" (White, 1988:187). The model of learning put forward by White suggests that as well as " providing training in motor skills, the laboratory should be a source of episodes that form attitudes, make propositions meaningful and develop cognitive strategies useful in learning and problem solving" (White, 1988:188).

In his paper on a rationale for practical work, Woolnough writes that we as educators should "be concerned ... with introducing students to the important body of scientific knowledge, that they might understand and enjoy it". He continues to write that students are "essentially active in the learning process in which they are continually enquiring, testing, speculating and building up their own personal constructs of knowledge" (Woolnough, 1991:33).

In short, the many references above which argue against the effectiveness of practicals are based on privileged middle class learners. This is in contrast to the students discussed in this research. Privileged learners have been exposed to a different education system from that of the disadvantaged Black South African student majority, such as, Mangosuthu Technikon students. The opportunities which privileged learners have had during their secondary studies incorporate: teachers with vast experience in Chemistry practicals, and the availability of resources to enhance the Chemistry courses.

Privileged students are also informed by the assumption that scientific theories and principles are based on experiment, which Mangosuthu Technikon students have not had the privilege of experiencing, and the integrated curriculum approach followed by the privileged system allows the freedom of correlating lecture with laboratory. The writer has had ample opportunity to observe the backgrounds from which Mangosuthu Technikon students come. The writer's involvement with secondary schools and their students has shown that the lack of chemistry practicals is perceived by the students to have a detrimental effect on their studies and, when subjected to practical work, they gain increased interest in and involvement with their studies. As stated before, Mangosuthu Technikon students enjoy the practical work in their courses. The opportunity to observe and experience is regarded highly by these students who have been subjected to 'chalk and talk' methods of tuition only.

Technikon bridging students are attempting to redress the problems of their secondary schooling and prepare themselves adequately for formal tertiary studies. These students will, on successful completion of the bridging programme, move into a formal course and continue to train as technicians. Perhaps one of the most important considerations to bear in mind is that the objective of technikon courses is not the development of pure scientists but rather the training of competent technicians for industry. One must bear in mind, then, when analysing the various arguments for and against the effectiveness of laboratory work, that we are investigating the role of practical work and its effect on the training of technicians (and not pure scientists) at technikons in South Africa. John Monaghan of ICI, UK stresses the need of industry for "technical experts" who can work and communicate (in Education in Britain, 1992:91).

3.6 CONCLUSION

Students studying towards a National Diploma: Analytical Chemistry or National Diploma: Chemical Engineering at Mangosuthu Technikon have come mainly from disadvantaged backgrounds. The courses they are following aim to train them as technicians and the formal courses incorporate a practical component. The practicals of the formal course demand certain knowledge and skills of the student. If from the very outset of their studies they experience such difficulties as not even recognising glassware for their practicals, then the rate of their success will be severely hampered. A student in any aspect of study needs to feel comfortable and familiar with his or her subject. The Pre-Technician Course for technicians at Mangosuthu Technikon is a course which helps prepare students for the formal course.

The practical component allows the student time to recognise and identify glassware and hardware relevant to practical work. When the student is familiar with such apparatus, he or she will then be confident enough to begin using it, setting it up for various experiments and finally to coming to terms with actually carrying out an experiment by him or herself.

Bratton emphasises that there are complementary essential skills to be learnt in the Chemistry Laboratory, "such as team work, presentational skills and communication, which can be effectively developed during practical work"(in Education in Chemistry, 1994:28). A variety of learning options offered in a practical session should enable a student to learn in under more motivating circumstances than 'chalk and talk' delivery.

Johnstone, Sleet and Vianna (1994) researched changes to an undergraduate laboratory course in Chemistry and presented their findings in an interesting paper. The need for a change in laboratory courses, they discuss, was that students in a normal three hour practical session are subjected to a "torrent of information; copious written and oral instructions, skills to be recalled, theory to be recalled, observations and deductions to make" (in Studies in HE, Vol. 19, 1994:78). They argue that many of the students, on top of all that, have to overcome language and mathematical hurdles as well as the physical logistics of where to find everything in the lab. With each new experiment a student has to do (where very little repetition is encountered), he faces a new deluge of problems. If he was able to repeat exercises, the operation would be simplified. In a formal course, however that is seldom the case and the student is, in essence, virtually a first time learner each time he or she enters the lab. The student then merely follows a "recipe" type of manual with little or no intrinsic reward.

The Pre-Technician students at Mangosuthu Technikon face all of the above hardships. It is important that the bridging course is designed to help students cope. The Pre-Technician practical laboratory courses that a potential tertiary learner would be involved with offers the learning of basic skills in an organised way at the beginning of the course. This has the advantage of being easily repeated until the skills are mastered and which ensures "later experimenting is not disrupted by learning simple techniques" (Meester and Maskill, 1993:156). The student can then concentrate more on the chemistry involved than worrying about the mastering of the skills. Practical work can also be structured in such a way as "to make important contributions to the learning of theory" (Mitchell and de Jong, 1994:177).

The initial skills emphasised in the Pre-Technician Chemistry practical course are simple manipulative skills and skills of gathering, handling and sometimes interpreting data. Such skills are very proper and worthwhile, according to John Carnduff of the University of Glasgow, when he presented views of industrialists, educationalists and academics concerning Chemistry degree courses. He emphasised the need for Higher Education institutes to make use of varied learning situations and practical work. He went on to say that practical work should be seen as a "vehicle" for developing general skills, such as analysis of decisions, planning, assessments of accuracy, hazards, costs and time management, which can be blended with the experience of preparations, analysis and measurements (in Education in Chemistry, 1992:91)

To summarise, Kirschner (1992) sees the general purpose of practicals being to aid students in imposing intellectual order on data. This can be achieved by involving the learner

> in the use of logical procedures and strategies, to demonstrate the implications of scientific theories and laws, to provide experience in asking good questions of nature, to provide practice in recognising regularities, symmetries, diversities and commonalities among observations (Kirschner, 1992:17).

Practical work in the bridging course is demanded by students. They feel that since school Chemistry was not an experimental science (for them it was not meaningful as they couldn't relate to it directly) amends should be made at least at the foundation level for tertiary education. Practical work is also demanded by the staff involved with Chemistry tuition as they, together with the industry feel that students need to comprehend the work of a technician as well as, perhaps, ultimately that of a qualified chemist.

Professor JC Bradley who believes students cannot be expected to comprehend in the abstract, that which should be experiential, has the following to add to the argument:

> Professional chemists can be relied upon to state categorically that chemistry is a practical subject and that practical work is an integral part of chemical education (in Chemical Processing SA, 1997:11).

Mobilising young black people into science, engineering and technology is necessary to meet the "developmental needs of South Africa and reposition our country as an efficient, high-technology competitor in world markets"(Scientech, 1995:4). The practical skills learnt by potential tertiary students is a positive step towards that goal.

CHAPTER FOUR

THE DESIGN OF THE MEASURING INSTRUMENT

4

4.1 INTRODUCTION

Chapter 4 discusses, as Johann Mouton (1996) describes it, the 'operationalisation' stage of this research. It outlines how a measuring instrument was constructed, the sampling population was decided on and the data was collected, analysed and interpreted (Mouton, 1996:66). It is interesting to read that Mouton acknowledges that the "human senses are our 'first-order' measuring instruments, even if they are qualitative" (Mouton, 1996:67). The writer was encouraged by this and has made use of her own senses during this research, and where justifiable, has made opinions based on these.

The writer decided that the measuring instrument for the initial collection of data would be a questionnaire rather than interviews. Mailed questionnaires (the most commonly used survey method) have distinct advantages and disadvantages which Isaac and Michael (1990) clearly explain in their handbook. They are inexpensive and wide-ranging, they can be simple and clear, they are self administering and, of course, they can be anonymous. The disadvantages are that one might get a low response rate, there is no assurance that the questions are interpreted in the same way by everyone, and there is no assurance that the respondent was actually the one who answered. To minimise such disadvantages the writer had to make initial contact with suitable respondents. This enabled the writer to explain reasons for the questionnaire as well as to provide fuller explanations to ensure questions were fully understood. The writer then made numerous follow-up calls to ensure the questionnaires were returned. The writer also had access tofax lines and E-mail addresses, which meant in many cases that a respondent received a personal copy of the questionnaire.

4.2 THE QUESTIONNAIRE

In order for a questionnaire to be effective and serviceable the questionnaire has to be relatively simple and designed correctly so as to find out facts and "what is really going on in people's minds" (Johnson, 1992:118).

A questionnaire was the instrument by which the writer acquired information from the relevant tertiary institutions concerning practical work for students enrolled on a Pre-Technician Course or equivalent bridging course. The writer had previously contacted technikons in 1995 but an update was necessary.

Very little is known (by technikon personnel) about the organisation of other technikons' bridging courses and, in some cases, even the content thereof. An initial questionnaire allowed the writer to obtain information concerning the organisation of the practical courses as well as the content of those courses. Knowledge of course organisation and content were necessary if recommendations for changes to such courses suggested themselves during the research.

It was also important for the writer to receive not only course information from technikons but also information concerning interactions between lecturers/demonstrators and students, students' attitudes towards practical work, and students' interactions among themselves. Consequently, a visit with more detailed questions would follow.

4.2.1 PRIMARY CONSIDERATIONS

Primary considerations for the development of the questionnaire were:

What type of information would be necessary - quantitative or qualitative?

What were to be the focus areas of the questionnaire?

It was decided that qualitative and quantitative information would be necessary. The four focus areas for each technikon would have to be:

4.2.1.1 **Before** (the bridging course)- Information should be gathered about students prior to their enrolling on a bridging course, to ascertain what type of education students had experienced in their secondary schooling years and their abilities on entering the bridging course.

4.2.1.2 **Course Structure and Design** - What constitutes a bridging course and what are the objectives of such a course. Are all tertiary institutions the same? Where are the differences? Why are there differences? What are these differences?

4.2.1.3 **Course Delivery** - What actually takes place during such a course (the practical course content, the manner in which such courses are conducted, the content and sequencing of events, the assessment of practical work, the importance of practical work in terms of overall performance of the student, commitment or not of staff and students to practical work)?

4.2.1.4 **After** (on completion of the bridging course) - One needs to determine the success or otherwise of such a course, by tracing its effect on subsequent courses.

Once the four focus areas were clear then the information required in each area needed to be determined. That gave rise to a questionnaire of six sections.

4.3 DESIGN OF THE QUESTIONNAIRE

4.3.1 Section A: BEFORE

A brief explanation was given so students would understand the purpose of the questionnaire.

This was a short questionnaire to students, in order to build up a profile of a student entering a bridging course (i.e. the capabilities he or she has when arriving at the institution). Both Quantitative information (eg Matriculation results) and Qualitative information (students' evaluations of their secondary schooling experiences) was needed.

Once that was determined, the writer had to decide whether open-ended questions, two-way questions or questions requiring a specific answer would be used. In questionnaires to students used previously by the writer and referred to herein, some questions were open-ended. That was done to acquire as much information as possible, however vague, which does admittedly mean that responses might be difficult to interpret (after Johnson, 1992). The students, however, were free to write down more than was requested, so interesting and noteworthy information was obtained by the writer. However, the type of information required from the students for the purposes of this study determined that questions be designed so as to elicit specific answers.

4.3.1.1 **Section B:** This was a separate short section to build up a profile of the institution as well as its bridging course. The writer had to decide which member(s) of staff would most likely be able to supply the relevant information about the institution and the appropriate bridging courses. Once the person(s) had been identified, this section was drawn up.

4.3.1.2 **Section C:** This section was also short and was also aimed at the respondent identified to answer Section B. It supplied data collected from prospective students, outlined the institution's actions regarding that data, said whether students are evaluated prior to entrance or not, and supplied the actual entrance criteria applied by each tertiary institution.

4.3.2 Section D:ACTUAL

This section was answered by either the same person identified to answer Section B or a member of the bridging course staff, and allowed the writer to obtain a broad picture of each institution's bridging course. It was a fairly lengthy part of the questionnaire so that the writer could ascertain whether all bridging courses are similar and whether they can/cannot be compared.

a: The writer needed to find out the history of the bridging course, and future plans for the course. Does the bridging course have formal recognition? How committed are the institution, the staff and the students to the bridging course's objectives and proposed outcomes?

b: The writer needed to find out if practical work is desired and if so by whom.By the tertiary institution, by the staff, by the students, by the community or by industry? Such information allowed the writer to assess the importance of practical work in such a course.

c: It was necessary to know who was involved/responsible for designing the practical course and whether it had been evaluated and updated. If so, by whom, why and when?

d: It was necessary to know the rationale for the objectives of the inclusion of practical tuition in the bridging course. Who decides on such matters? Does industry have input/influence? Is there an order to the experiments in the practical work? If yes, what is the rationale for that order?

e: What comprises the curriculum of such a course? What particular laboratory skills are taught in such courses? Is there a particular order for the teaching of those skills and why? Are there any unusual or interesting features in the aims and objectives of individual practicals? Is a common core of skills taught? Are there any curricular links between practicals and theory? If so, how is that achieved and why in that particular manner? Do any links exist between skills taught in the bridging course and those needed by other levels? What is the relationship between a bridging course and a formal course, vis-a-vis practicals. One would also need an in-depth look into practicals, concerning their time schedules, pre and post laboratory work, write ups and assessment

4.3.3 Section E:DURING

It was necessary in this section to obtain quantitative data to analyse what learning was intended during the operation of these bridging courses. Such statistical information would be necessary to enable the writer to comment on the success, or otherwise, of students taking part in the bridging courses. If objectives included basic skills/techniques, how were these assessed and how indicative were the practicals in ensuring that was done? In this area, feedback from staff involved in the formal courses was needed. That enabled the writer to determine the abilities of students entering the formal course from the bridging course

The information had to involve approximately the following 3 areas: the number of students who registered, the number of students who wrote the examinations, and the number of students who passed. An analysis of the students' performances (practically, theoretically and overall) was carried out.

Qualitative analysis then assessed and evaluated the practical work and the performances of students. The type of information required in this section included: the methods that are used by the tertiary institutions to assess and evaluate; the importance of such information to the institution; what records are maintained on the bridging course; the performances and results overall; and if and what follow up work is done to review or refine the bridging course. This type of information indicated the degree of importance institutions place on their bridging courses.

Information about the demonstrators and lecturers involved in the practical sessions needed to be known: the methods they use for tuition, the technology they use to enhance their methods, their manuals for students, what is expected (by the lecturer) of a student's laboratory report; how each practical writeup is assessed; how performance in the lab is evaluated; what determines the final mark; whether it is necessary to pass practicals in order to advance to the formal courses.

4.3.4 Section F:AFTER

It was insufficient to collect information from only before and during the bridging course. The questionnaire's final section, which enabled an analysis of a completed course, once again included quantitative and qualitative analysis in order to achieve a proper assessment.

4.3.4.1 Quantitative Analysis (Section F)

This information included the number of students successful at the bridging course level, the number of students continuing to formal level, and the tracing of students through various formal levels. Evidence of students' overall successes indicated the effectiveness of the bridging course in terms of improvement on schooling.

4.3.4.2 Qualitative Analysis (Section F)

The writer attempted to collect information on whether students had been questioned about the impact of the bridging course, about their actual practical work and experience, or their opinions of the course.

The views of industry concerning practical work in bridging courses was of added significance to this study. Depending on the views expressed it served to emphasise the need for tertiary institutions to include and/or stress practical work or not. Any particular strengths gained from bridging courses, which might ensure success in industry or in further studies, was valuable information to collect. Consequently (see 4.4 below), an attempt was made to supply some such information.

4.4 ADDITIONAL METHODS USED

4.4.1 TELEPHONE SURVEY

The writer also used the telephone to procure information from persons involved in bridging courses and with in-service trainees, where interviews or questionnaires were impossible to carry out. It was never a primary method of data-gathering as the expense of such calls was high (respondents were situated throughout the country and the questionnaire was long). The writer did not want respondents to make on-the-spot replies either. The questionnaire required thoughtful responses.

4.4.2 INDIVIDUAL AND GROUP INTERVIEW

The writer made use of both these types of interviews for her visits to the technikons and industry. These interviews were used as follow-up meetings to the questionnaire responses and were particularly useful for covering areas not well answered in the questionnaire. Group Interviews situation were conducted with students at the technikons visited. The advantages of that are as Isaac and Michael (1990) wrote, efficiency and economy, a revelation of group interaction patterns, and, as the writer found out, encouragement to all participants to make valuable contributions. Disadvantages, such as intimidation and the suppression of individual differences, meant that the writer also broke the group size down at times, into pairs of respondents, which assisted in encouraging all students to participate. The writer was fortunate that no members in the group tried to manipulate or influence the interview. All comments were welcomed by the writer and this encouraged students to speak their minds freely.

A visit to the staff involved was imperative to see first-hand the administration of bridging courses. Such individual interviews also allowed in-depth discussion, which demanded flexibility and adaptability by the writer. She favoured such free responses but acknowledges that findings from such interviews are difficult to summarise. Isaac and Michael (1990) emphasise the need for a skilled and trained interviewer to carry out such interviews and, as the writer is not such a person, she feels it would be better to leave such matters to the right people for the purposes of follow-up research.

4.5 ADMINISTRATION

The writer contacted all the technikons in South Africa prior to sending out the questionnaires. She approached the relevant personnel involved in bridging courses, or any such course offered by that institution involving academic support for disadvantaged students. The writer explained the reason for the questionnaire and requested their assistance. All personnel contacted at the various institutions were helpful and affirmed their willingness to answer the questionnaire as timeously as possible. The questionnaires were then sent out to all the technikons in South Africa. Of the fourteen questionnaires sent off, eight institutions responded. The remaining institutions failed to respond despite numerous follow-up attempts.

4.6 CONCLUSION

The questionnaires enabled the writer to achieve the following:

a: first hand responses from students (other than students at Mangosuthu Technikon) concerning their secondary schooling.

b: an overview of the bridging courses on offer in South Africa: selection methods, course content, assessment procedures, promotion requirements, and course evaluation procedures.

c: limited statistical data.

CHAPTER FIVE

ANALYSIS OF RESULTS OF THE QUESTIONNAIRE SURVEY TO TECHNIKONS

5

5.1 INTRODUCTION

This chapter analyses the bridging courses for aspirant chemical technicians, which are presented and administered by some technikons within South Africa. Note that, when the writer contacted personnel involved in bridging courses prior to mailing the questionnaires, she learnt that one region has a university which works closely with the local technikon in delivering bridging courses (the questionnaire was answered and returned by a representative of the university).

The responses to the questionnaire allowed the writer to build a suitable profile of each course on offer. The construction and design of the questionnaire, which has been explained in the previous chapter, allowed the writer to present the relevant information in a suitable format.

There are fourteen technikons in South Africa:

ML Sultan, Natal, Mangosuthu, Witwatersrand Pretoria, Free State, Vaal Triangle, Cape, Peninsula, Border, Port Elizabeth, North West, Northern Gauteng and Eastern Cape.

Three of the polled technikons do not offer bridging courses for aspirant chemical technicians. Eleven questionnaires were, thus, sent out to personnel who had been contacted by the writer. Eight responses were received.

The writer had been in communication with all technikons since 1994, when she first became interested in the assessment of bridging courses. The writer visited the technikons in 1995 and 1997 and was involved in a National Workshop to discuss a way forward for bridging courses, held at Mangosuthu Technikon in the second half of 1995. The eight responses to the questionnaire, together with the writer's knowledge of the bridging courses at the institutions which did not reply, enabled the writer to discuss and debate responses to the questionnaires and to formulate conclusions.

Note: The presentation of tables within the following section's text are pertinent to a relevant question and will not be labelled individually. The graphical representations however are individually labelled and indexed as Figures.

5.1.1 ANALYSIS OF QUESTIONNAIRE RESPONSES

SECTION A:

Only four technikons responded to this section.

Border Technikon:	63 students
Technikon Witwatersrand:	31 students
ML Sultan Technikon:	11 students
Mangosuthu Technikon:	28 students
Total:	**133 student respondents**

Question 1:

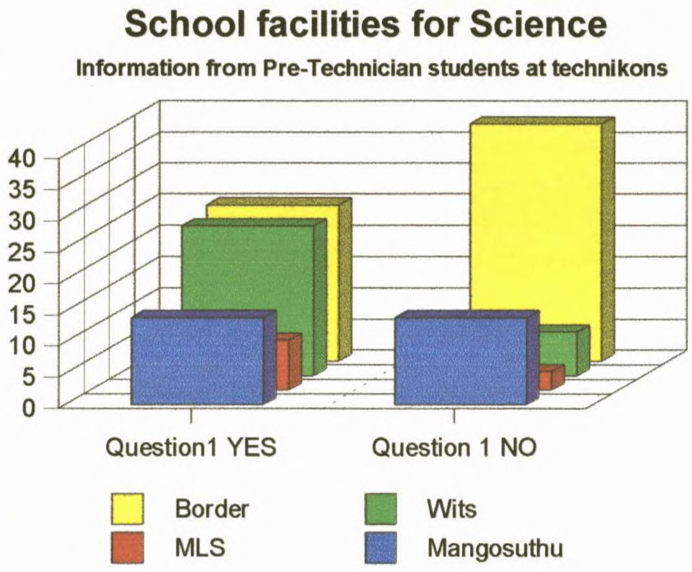
Were facilities for Physical Science practical work available at your school?

Responses

A small majority of students (71), responded that facilities for practical Physical Science were available at their schools. 62 students did not have such facilities.

Technikon	Question 1 YES	Question 1 NO
Border	25	38
Wits	24	7
MLS	8	3
Mangosuthu	14	14
Total	**71**	**62**

Figure 3: Pre-Technicians - Who had School facilities for Practical Science (secondary school)?



Comments

Border Technikon is situated near a smaller urban area than that of the other three technikons. The probability of drawing students from rural areas then is greater than the other technikons who are closer to large urban and peri-urban areas. Mangosuthu Technikon is situated in Kwa-Zulu Natal. Kwa-Zulu Natal because of its small size, high population density and vast number of learners, would appear to be one of the most educationally deprived regions in South Africa. Mangosuthu Technikon whose students are mainly drawn from the local community of Umlazi, had an equal proportion of students responding "yes" and "no" to this particular question. The Witwatersrand Technikon however, whose students are drawn from a much wider and more heterogeneous (of the various race groups within the country) area, had 24 students responding that facilities were available and only seven students responded that facilities were not available.

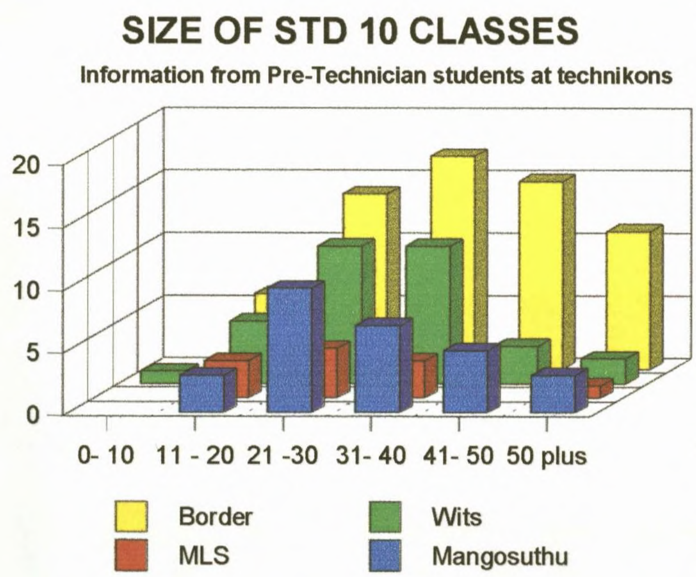
Question 2:

What was the number of pupils in your Physical Science class?

Responses

Technikons	**0- 10**	**11 - 20**	**21 -30**	**31- 40**	**41- 50**	**50 plus**
Border		6	14	17	15	11
Wits	1	5	10	10	3	2
MLS		3	4	3		1
Mangosuthu		3	10	7	5	3
Total	**1**	**15**	**39**	**38**	**23**	**17**

Figure 4: **Pre-Technicians - Number of pupils per science class (secondary school)**



Comments

Border Technikon results are indicative of the situation in the province. The Eastern Cape is one of the country's most educationally needy areas. The matric results in 1994, 1995 and 1996 show that the Eastern Cape has had a decrease in the number of matriculants who passed. By comparison other areas have had a slight increase in the number of matriculants who passed (RIEP, Vol 17:11). In 1995 the Eastern Cape was one of three provinces who had a matric pass rate of less than 50% which is a "matter of concern as a large percentage of the total school population (44%) resides in these three provinces" (RIEP, Vol 16:11). For the rest of the technikons however , it can be seen that a majority of students at each technikon attended rather large classes. Group sizes in excess of thirty were common.

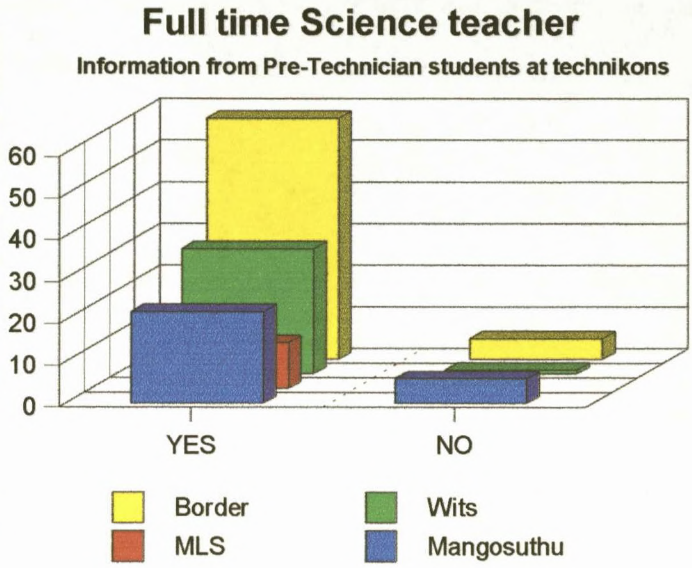
Question 3:

Did the class have a fulltime Physical Science teacher?

Figure 5: Pre-Technicians - Who had full time science teachers (secondary school)?

Responses

Technikon	YES	NO
Border	58	5
Wits	30	1
MLS	11	
Mangosuthu	22	6
Total	**121**	**12**



Comments

A positive factor emerging from this question is that a majority of students had a fulltime Physical Science teacher (i.e. 121 answered yes and only 12 answered no). But, the likelihood of these teachers being fully qualified is not strong. In 1990, 22% of African and 14% of Coloured teachers did not have even a school-leaving qualification; a further 51% and 39% respectively were professionally underqualified. (Edusource No 4; December 1993:3)

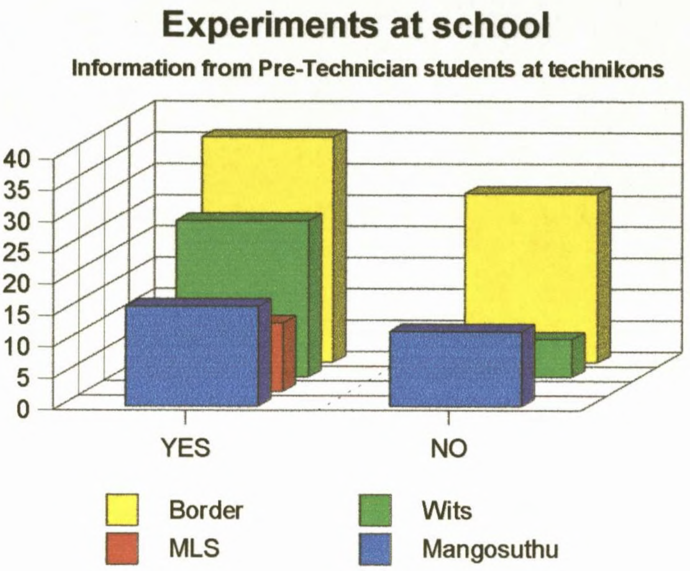
Question 4.1:

Were Physical Science experiments conducted at your school?

Figure 6: Pre-Technicians - Who physically did any/some practical work (secondary school)?

Responses

Technikons	YES	NO
Border	36	27
Wits	25	6
MLS	10	1
Mangosuthu	17	11
Total	**88**	**45**



Comments

Physical Science experiments were carried out in a majority of the pupils' schools but the ratio of 2:1 is not favourable (i.e. 88 students responded affirmatively whilst 45 had not been so fortunate). It is a cause for concern that more than half did not have such opportunities. This could be seen as a direct result of under qualified teachers. In the next section of this chapter an analysis of students attending the Pre-Technician course at Mangosuthu Technikon will depict the unsatisfactory situation of students attempting to study further at the institution against an unsuitable educational background in Science tuition.

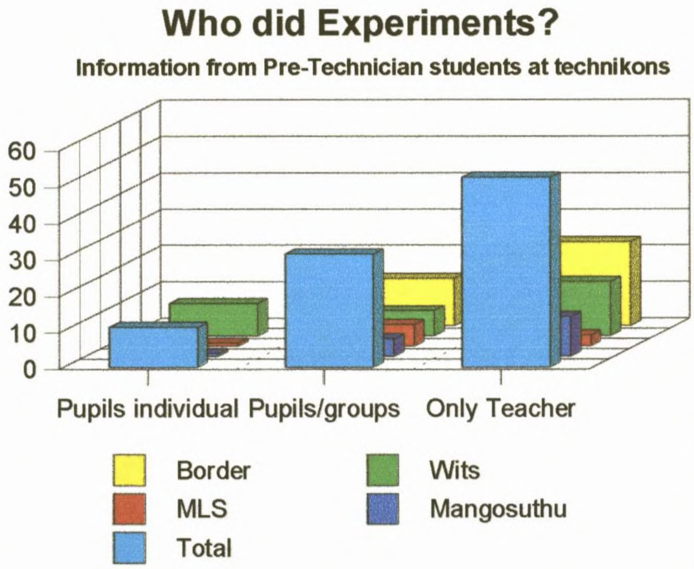
Question 4.2:

If yes was answered to 4.1 then who conducted the experiments?

Responses

Technikons	**Pupils individually**	**Pupils in groups**	**Only the Teacher**
Border		13	23
Wits	9	7	15
MLS	1	6	3
Mangosuthu	1	5	11
Total	**11**	**31**	**52**

Figure 7: Pre-Technicians - Which person (s) conducted the practicals (secondary school)?



Comments

Problems of under-qualified teachers appears to be of consequence again. Unfortunately, from this total of 88 only 11 students did the practicals individually, 31 worked in groups and the balance had a demonstration from a teacher. Once again the demands of the formal course of study for technicians are unlikely to be met since the majority of these students have had no, or only a little, hands-on experience and in the formal course they need to know how to work independently. This is confirmed by Hegarty-Hazel when she writes, "one possible strategy for enhancing student learning and memory of scientific knowledge is by active involvement rather than watching a teacher demonstration" (Hegarty-Hazel, 1990:123). Student laboratory work has increased in importance over the years, according to Hegarty-Hazel, since a greater emphasis on scientific processes is desired as opposed to mere scientific knowledge.

SECTION B:

Question 1 - Question 6:

Number of questionnaires sent out:	11
No of questionnaires returned:	8

NOTE: Two of the technikons who responded preferred not to have the names of their institutions written into the thesis. They will be designated as X and Y respectively throughout this section of the chapter.

Respondent's positions in their institutions:	1 Associate Director
	1 Coordinator
	1 Professional Officer
	4 Lecturers
	1 Technician

Of this group five were directly involved in the particular course while three were not.

The departments in which the respondents held posts varied except for two, who were both from Chemistry. Others were from Mechanical Engineering, Mathematics, Tertiary Foundation, Access, Strategic Services and other academic departments.

The names given to the particular course varied. Three technikons named the course "Pre-Technician" while one didn't have a name for it at all. Others names are: Science Bridging, Tertiary Foundation, Career Preparation and Augmented 1. Of all these courses, the three Pre-Technician and the Science Bridging courses are 6-month courses while the others last a year.

(Note: Tables representing response figures are pertinent to the relevant question and are not labelled individually. All graphical representations however are labelled and indexed as Figures).

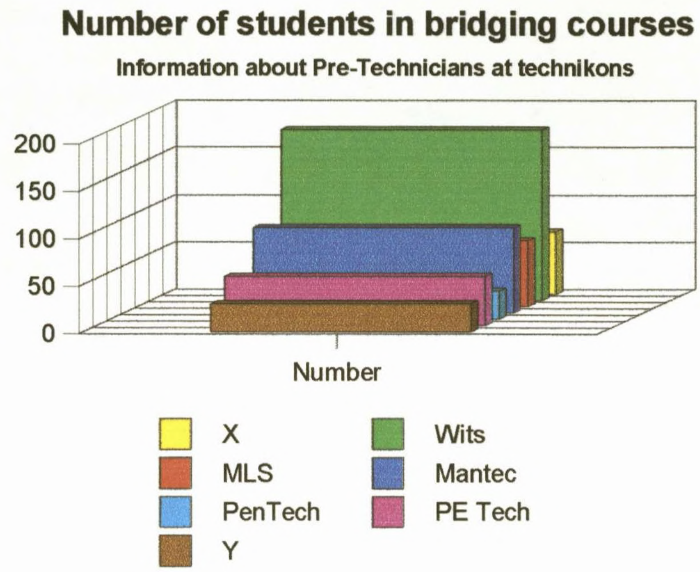
Question 6:

Number of students on the course

Figure 8: Pre-Technicians - Number of students in the bridging courses (1997)

Responses

Technikons	Number
X	66
Wits	180
MLS	70
Mangosuthu	90
PenTech	30
PE Tech	52
Y	30
Total	**518**



Comments

The number of students registered for bridging courses averages 74 per technikon, the lowest number registered being 30 and the largest number 180.

The following data on practical classes have been collected from seven institutions since Cape Technikon has no such course operating at present.

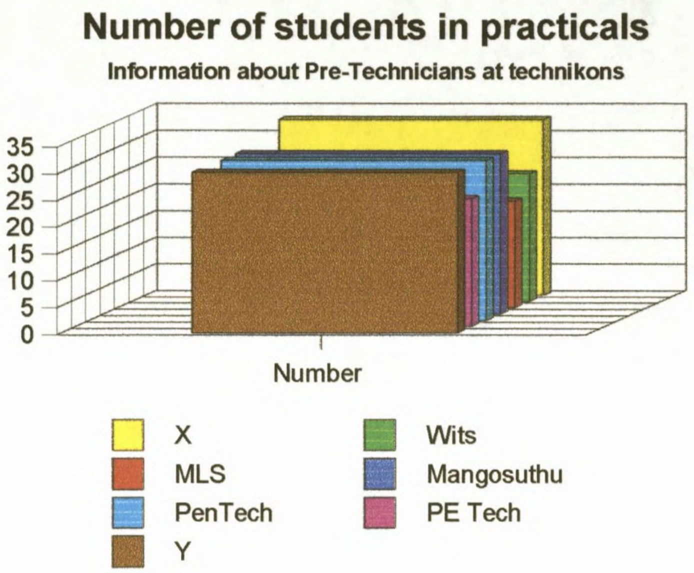
Question 7:

Number of students in each practical group:

Responses

Technikons	Number
X	33
Wits	24
MLS	20
Mangosuthu	30
PenTech	30
PE Tech	24
Y	30
Total	**191**

Figure 9: Number of students in practical groups



Comments

It is encouraging that practical classes are being kept to a manageable size which indicates that institutions are committed to prioritising good practical experience for their students.

Question 8:

Ratio of lecturers to students in each practical session:

Responses

Technikons	Ratios	Technikons	Ratios
X	1:33	Peninsula	1:24
Wits	1:24	Port Elizabeth	1:24
MLS	1:20	Y	1:30
Mangosuthu	1:30		

Comments

There is nothing unusual in the above data and one lecturer in charge of practical classes of such sizes is acceptable.

Question 9.1:

Are student demonstrators used for practical sessions?

Responses

Technikons	**YES**	**NO**
X		no
Wits		no
MLS		no
Mangosuthu		no
PenTech	yes	
PE Tech	yes	
Y	yes	
Total	**3**	**4**

Comments

Three technikons allow student demonstrators to assist in the practicals. This not only providese provides Pre-Technician students with extra assistance in their work but also enables the student demonstrator to gain experience in practical tuition. Peer tuition is proving to be a popular method of enhancing tuition.

Question 9.2:

If yes then how many in each practical session?

Responses

Only 1 demonstrator was used in each practical session by those three technikons that answered yes.

Question 10:

Do you have any objection to my attaching the name of your institution to the data you have submitted?

Responses

Two technikons answered yes and six no.

SECTION C:

Question 1.1 and 1.2:

Are students who apply to enter the bridging course evaluated prior to acceptance or registration?

If YES, then how?

Responses

Six technikons evaluate students prior to acceptance or registration for the bridging courses. The means by which this is done varies and is as follows:

Lead the Field Africa tests

Aptitude tests overseen by the Student Counselling department

Entry tests in Maths and Communications

Three institutions make use of the *Swedish Formula - Candidates who meet minimum requirements are ranked academically on the basis of a formula in which points are allocated in respect of Matriculation subject passes according to a specific table* (Faculty of Engineering, University of Natal, Handbook 1995)

Sometimes *interviews* are conducted with potential students.

Question 2.1:

What are the entrance criteria for the bridging course?

Responses

Entrance criteria for the bridging courses are similar among the institutions. Two institutions demand at least 12 points on the Swedish Formula and/or Higher Grade (HG) E or Standard Grade (SG) C in Mathematics, Physical Science and English. A third institution allows for a

National Technician Certificate 3 to be considered. One institution favours 'more than' 23 Swedish points or 'more than' 95 on General Scholastic Aptitude Test (GSAT) which is a Human Sciences Research Council test, commonly used for aptitude testing at High Schools. Yet another will accept Matric passes with a minimum SG symbol E in Mathematics, Physical Science and Language whereas another institution requires only a minimum F symbol on SG for Physical Science and Mathematics. Yet another requires only a pass on SG for Physical Science and Mathematics. One institution chooses candidates who fall short of qualifying for the formal course but who are from disadvantaged backgrounds.

Question 2.2

How are these criteria evaluated?

Responses

The evaluation of these criteria is commonly moderated by the Senior Certificate but two technikons make use of verbal and nonverbal subtests as well as interviews so as not to be inflexible. The technikon which chooses candidates that do not qualify for the formal course but would benefit from such a course merely goes by "gut feel" (quote from an informal interview with one of the respondents).

Question 2.3:

Are these criteria recorded and compared to final marks accomplished in the bridging course?

Responses

These particular criteria are recorded by five technikons and used for comparison with final marks obtained by these students in their bridging course. Two technikons do no recording of such data and one technikon failed to answer this question.

Question 3.1 and 3.2:

Are the matric symbols recorded for future reference?

If YES, are these matric marks compared to the final bridging course marks for similar subjects?

Responses

Seven technikons record matric results for future reference but only three technikons compare them with the final bridging course results. Mangosuthu Technikon has however done this in the past, particularly in 1995 (after Lafferty, 1995).

Question 4:

What grasp of laboratory work or practical experience, in your observation, do these students have on entering the bridging course?

Responses

It was unanimous that students entering the bridging course have very little, if any, experience in practical work. This corroborates the graphical representations (see Section A) presented earlier, concerning students' responses about practical work during secondary schooling.

Question 5.1 and 5.2:

Has data ever been collected regarding the school background from which your students come?

Responses

Eight of the technikons who responded do not collect data concerning the school background from which their students come. The writer has independently collected such data from Pre-Technician students, which has allowed her to draw certain conclusions about the schooling background of her Pre-Technician students. This data was presented earlier in Chapters One and Two and will be discussed later in this chapter.

SECTION D:

Question 6.1 and 6.2:

Does the bridging course have formal recognition?

If YES, detail this recognition.

Responses

With one exception, the technikons responded that their bridging courses had formal recognition within their own institution - that students on passing the bridging course are accepted into formal courses.

Comments

The writer has collected data from Pre-Technicians at Mangosuthu Technikon to assess their feelings. A group of students attending the formal course in 1995, but who had previously attended a bridging course, were asked:

Would you prefer the Pre-Technicians' course to be?

a)incorporated into the formal course (i.e. extend the actual diploma course by 6 months)?

b)a separate certificated course?

c)a separate course having subjects with different credit ratings?

d)remain the same?

The responses are tabulated below

a	b	c	d	Total
8	4	11	2	25

Clearly the students questioned did not wish the course to retain its present degree of recognition, which merely enables the student to progress to S1 if all subjects are passed (the course may not be repeated). The majority appeared to prefer the course offering subjects with different credit ratings. The next most popular choice was that it be incorporated into the formal course.

Question 7:

How long has the Institute's bridging course been implemented?

Responses

Two technikons have run such courses for more than 10 years, four technikons have between two and five years' experience with bridging courses, while two technikons have been in operation for only two to five years.

Question 8:

What subjects does the bridging course consist of?

Responses

All courses consist of English or Communications, Mathematics and Science, or Chemistry and Physics separately. Some courses include Drawing and cognitive skills and one technikon even includes Biology.

Question 9.1:

Is practical work considered desirable for the bridging course?

Responses

Without exception all technikons consider practical work to be desirable. This once again appears to prove that practical work has an important role to play in students' tertiary studies.

Question 9.2:

If YES, by whom?

Responses

It would appear that staff directly involved head this train of thought. "Staff" gets 6 votes, with "institution" a close second (5 votes) and then "students" (4 votes). Full commitment from the staff is unanimously recorded while four institutions record full commitment from institution and students as well.

Comments

Such responses reiterate the desirability of practical tuition and its importance in the training of technicians.

Question 10 (Unfortunately one technikon failed to answer Questions 10 to 15):

If practical work is included in the course, to what extent are the following stakeholders committed to its success?

Responses

Commitment from the institution - Full or some or none

Four technikons responded that there was full commitment from the institution. One replied that there was only some commitment from the institution and one technikon responded that there was no commitment from the institution.

Commitment from departmental staff - Full or some or none

Seven technikons responded that there was full commitment from the departmental staff.

Commitment from the students - Full or some or none

Four technikons responded that there was full commitment from the students and three technikons replied that there was some commitment from students.

Question 11:

What are the objectives for including practical tuition in the bridging course?

Responses

A clear understanding of the importance of practical work (in various technikon courses) is shown here. Three technikons agreed that practical tuition was intended mainly to familiarise students with laboratory work and laboratory equipment by the teaching of manipulative, observational and measuring skills. It was also stated that practical work provides an opportunity for honing students' reporting skills. Another popularly expressed objective was to develop practical skills and acquire training in laboratory skills as well as to provide hands-on experiences of science in action. A similarly stated objective is to ensure better understanding among students through their using their senses to gain knowledge. Yet another technikon sees practical tuition as an integral part of a Science subject while another recognises the relevance of this tuition to theory and to industrial processes.

Comments

Hegarty-Hazel (1990) refers to findings obtained in England in the seventies, where it is reported that objectives referring to experimental skills and problem-solving procedures achieved high mean ratings. These responses are in line with the discussion in Chapter Two where the argument for laboratory work is debated.

Question 12:

How are these objectives measured at the end of the bridging course?

Responses

These objectives appear to be assessed continuously throughout the courses, by evaluation of students during practicals, assessments of write-ups handed in after each session, and through practical tests or examinations at the end of each course.

Question 13:

Who was involved in the design of the practical course in the bridging course?

Responses

Design of the practical courses in the bridging courses appears to have been carried out by the staff of the Chemistry departments (3 answers for this) and in some cases one particular lecturer (2 replied for this). Two technikons did not answer and one technikon replied that it was unknown who had designed the practical course.

Question 14.1 and 14.2 and 14.3:

Has this practical course ever been evaluated and updated?

By whom?

Why?

Responses

Of seven technikons who responded to the question, four technikons have evaluated their bridging course and six institutions have updated theirs. This would appear to be a commitment to the continuation of better practical tuition. Once again staff in particular departments, or a lone lecturer, have been responsible.

Comments

> One important reason for monitoring is that it enables course designers to check that courses are achieving what had been hoped for, i.e. that hopes have become reality. Monitoring can lead to course improvement by the identification of isolated or pervasive problems - for example oversights, errors, gaps, repetitions, non-sequiturs, lack of clarity, lack of opportunity for practice in mastering laboratory skills and use of equipment. Besides revealing problems, monitoring can identify especially successful parts of a course; designers can then take steps to ensure these are preserved and fostered, increasing the chances that the success will recur (Boud et al, 1986:107).

Reasons given for evaluation and consequent updates are changes in class sizes (to larger sizes) and subsequent time constraints, as well as the changing abilities of students, resulting in more intensive basic training (less advanced material) being needed. The latter two statements were real and unprompted responses from the respondents to the questionnaire, which show clearly that chemical technician students are not adequately prepared for tertiary education and that intensive basic training, particularly in practical work, is needed to enable them to access tertiary education successfully. Previous courses were seen to be out of date and there was a need to improve the relevance of the practical assessment. Practicals needed to be more meaningful and more relevant to theory.

Question 15:

Does Industry have input or influence regarding the practical course content?

Responses

Surprisingly, industry has little input into, or influence on, the practical course content. Only one technikon acknowledged industry's influence on their course.

Comments

Further discussion concerning the relationship between industry and technikons is found in Chapter Six.

Question 16.1 and 16.2:

Is there a set sequence of experiments in the practical course?

Responses

All eight technikons have a set sequence of experiments in their practical courses. The rationale for that is detailed as follows:

Six technikons responded that practicals are sequenced so as to correspond with topics covered in the course's theory component and so the attempt is made to ensure practicals follow on to theory. Two other technikons agree that sequenced experiments allow for natural development of students by introducing them to different techniques in turn, with the simpler techniques first. In that way, a transfer of skills from one practical to the next will be accomplished.

Question 17:

Are the practicals in the course?

Chemistry practicals only

Physics practicals only

both Chemistry and Physics practicals

Responses

All eight technikons have both Chemistry and Physics practicals in the course.

Question 18.1 and 18.2:

What is the length of each individual practical session?

Responses

Four technikons have a 3-hour session for each practical each week and two technikons have 3-hour sessions on alternate weeks. One technikon has a Chemistry practical for two and a quater hours and a Physics practical for just one and a half hours. The remaining technikon has a 3-hour practical session for Chemistry but a 2-hours session for Physics practicals (see Question 21 below).

Question 19:

What formal qualifications are necessary for the lecturer who controls the practical sessions?

Responses

Seven out of eight technikons make use of qualified lecturers (a university graduate or person with a relevant M+4 qualification). One technikon uses personnel with a relevant M+3 qualification.

Comments

It has been stressed in an earlier chapter that a teacher/lecturer influences student's attitudes to practical Science work as well as their standards of performance in the laboratory.

> There is evidence that teachers who are cognitively well organised with good understanding of their subject matter and a capacity for effective planning, appear to enhance student interest in science (Hegarty-Hazel, 1990:144).

Such interest generated in the student will hopefully also encourage a general willingness to solve problems scientifically.

Question 20:

If demonstrators/assistants are used for the practicals, what qualifications are necessary for them?

Responses

Only four technikons make use of assistants for their practicals and such persons could be qualified technicians or students at a higher formal level.

Comments

The use of demonstrators or assistants has proved most popular in the formal level of Chemistry at Mangosuthu Technikon, as well as in some Pre-Technician courses. When Pre-Technician students were asked (1995) whether that concept was a good idea or not the response was 93 YES and only 8 NO. 90% of those students also confirmed their eagerness to do such supervisory work when they were suitably trained.

Question 21:

How many practical sessions are there per week for:

21.1: chemistry?

21.2: physics?

Responses

Six technikons have one session of Chemistry and one session of Physics per week. Two technikons have the sessions on alternate weeks.

Question 22 and Question 23:

Are the practical experiments coordinated with the relevant theory section of the course? Does each practical session link up with the previous practical sessions or is each practical session teaching an independent unrelated technique?

Responses

All technikons coordinate practical experiments with the relevant theory section of the course. (See Question 28 as well). Five technikons link each practical session to the previous one, whereas two maintain that each practical session teaches an independent technique (unrelated to the previous practical).

Comments

The cognitive as well as the psychomotor outcomes of laboratory work are extremely important so linking theory and practical work can be seen to be advantageous. Skills taught once and then repeated and exercised will enhance the performance ability of a technician. Professor David Weitzman, Chairman of the "Variety in Chemistry Teaching" symposium 1995 had the following to say during his opening remarks for the session "Transferable skills":

> But skills training cannot be done as 'bolt-on' activity. It needs to permeate the whole educational programme, progressively enhancing students' abilities as well as enriching the learning of subject specific material (Weitzman, 1995:41).

From another source it is stated that "continually stressing the purpose of the practical work and the relationship with theory is one way teachers can enhance the learning of scientific knowledge in the laboratory" (Hegarty-Hazel, 1990:128).

Question 24:

How many weeks are timetabled for practical sessions?

Responses

For all technikons, the practical timetable would appear to follow that of the conventional academic timetable. Most technikons answered that practical sessions are timetabled throughout the duration of the course.

Question 25.1 and 25.2:

Are students expected to spend time on pre-lab preparation?

If YES, how much time?

Responses

The positive response from seven technikons, who expect students to spend time on pre-lab preparation, is encouraging (only one technikon does not expect this). The time for such preparation varies from institution to institution, the variants being 15 to 30 minutes, 15 to 45 minutes and 45 to 60 minutes.

Comments

Pre-lab preparation ensures that students have done some sort of reading on the practical work to be covered. It should assist with interest stimulation and lead to a practical being carried out timeously as well as safely since the student is not working aimlessly /or carelessly. Such preparation time also sets a pattern for what the student can expect in future laboratory work; later project style laboratory work demands such preparatory exercises.

Question 25.3:

Do students have laboratory manuals covering all practicals?

Responses

All technikons answered that students have laboratory manuals.

Comments

This is encouraging, but often manuals are of a "cookbook" variety and do not offer students any particular challenges. Nevertheless, bridging courses have an important role to play, in allowing students the opportunity to take part in practicals. Earlier chapters have shown that many students' experiences in practical work are limited, so the practicals that they will be involved in will of necessity not be overly challenging.

Research work for the Edinburgh College of Education, titled "Techniques for the Assessment of Practical Skills in Foundation Science (TAPS) by Bryce et al, emphasises this fact and the following limited set of skills feature typically in such a course:

> skills of observation
> skill in recording information or scientific data
> skills of measurement
> skill in manipulation or dexterity
> skill in handling apparatus or in executing a procedure or technique,
> ability to follow instructions (Bryce et al, 1987:55)

The research determined that there are always cognitive challenges in such practical skills and they are not merely manipulative skills.

Question 26.1 and 26.2:

Are students expected to spend time on post-lab writing up?

If YES, how much time?

Responses

Seven technikons expect students to spend time on post-lab write-ups while one does not (students fill in data during the practical session). The time allowed for the writing-up is substantially more than for prep work. Again this varies with each institution but 30 - 60 minutes is popular and one technikon favours 120 minutes.

Comments

Report write-ups ensure that the student reflects on the practical completed and on what he or she has learnt from the experience. "Assessment must be more stimulating and interesting, even fun for the participants" (Bryce et al, 1987:8). In some cases the write-up should require consulting references, which will encourage students to make use of a Resource Centre and eventually, through such work, lead to all-round development of a tertiary student.

Question 27:

If lab reports (write-ups) are expected, are master blanks supplied and the student expected to fill in the missing data, or is the report written up entirely by the student?

Responses

Responses to this question are split five to four with the majority favouring master blanks and four favouring a full report.

Comments

Demands from industry include that students need to know how to communicate results efficiently and effectively. The communication exercise in writing up a report is justified thereby and all students should be encouraged to produce well formulated, written reports. Merely to fill in data is insufficient, considering the demands on experiential trainees at a later stage. However, the argument that a bridging course attempts to redress many problems that have arisen as a result of poor schooling suggests that reports of the 'fill-in' type are acceptable in a limited programme like this.

Question 28:

Are theory and practical sessions completely separated when taught, or are they lectured and taught as integrated subjects?

Responses

Interestingly four technikons answered that theory and practical sessions are completely separated when taught while four technikons teach theory and practical in an integrated fashion.

Comments

Hegarty-Hazel writes that students' reactions to labwork are influenced by the extent to which labwork forms a coherent part of their Science course. Several studies conclude that laboratory work should be integrated into the particular course of study. One such study, she claims, found that "60% of a sample responded that they best understood new subject matter if experiments were done during the exposition" (Hegarty-Hazel, 1990:142). Other studies, however, she points out, have found that students have a collection of concepts and beliefs on arrival at the laboratory which themselves may not be coherent and/or well integrated. The knowledge acquired during practicals may not necessarily then be advantageous if it is merely grafted on to the previous knowledge. "The issue of integration is much deeper than merely deciding when to offer labwork in the curriculum" (Hegarty-Hazel, 1990:144). There appears to be a worldwide problem with the integration of theory and practical work. At a symposium on "Variety in Chemistry Teaching 1996" a poster (Goedhart, 1996) was presented depicting the problematic " gap" between theory and practice. At the University of Amsterdam, Martin J Goedhart and his colleagues discovered that students cannot design experiments based on theoretical argument -- theory is simply not integrated with their practical work. In an attempt to solve this problem they are busy developing the necessary experiments. Goedhart (1996) is of the opinion that discussions about theoretical subjects which are relevant for the experiment are important. In a particular bridging course for engineers at Monash University in Australia the concept of integrating practicals with theory was demanded and much effort was put into this. Success appeared to be achieved not only in terms of what the researchers determined, that "Practical performance and linking practical work to theory improved significantly over the 13 weeks", but also by the comments of the students: "The chem pracs seem to be more relevant to the work we are doing. We are always relating theory to prac and vice versa", "much easier to understand and learn when linked. Instead of just doing as instructed from a book and not knowing why", and, "the pracs in bridging chemistry link directly to theory and hence try to build on the foundations made in lectures" (in Higher Education Research and Development, Vol. 13 of 1994:174).

Question 29.1 and 29.2 and 29.3:

What laboratory skills or techniques form part of the course?

Are there any links between skills taught in the bridging course and those taught in the higher formal levels?

Are there any links between skills taught in the bridging course and those required in the higher formal levels?

Responses

The laboratory skills and techniques which form part of the bridging course were detailed by all but one of the tertiary institutions. As discussed in Chapter Three there is a common core of skills on which most practical courses focus.

The common skills and techniques which each technikon stated are:

*use and setting up of basic glassware

*measuring of mass and volume

*use of top loading balances, stopwatches, thermometers, vernier calipers, Bunsen burners, pipettes and burettes

*titrations and separation techniques appeared in two technikons' listings

*sampling techniques were included in one technikon listing

*the making of observations, drawing conclusions and report writing were listed by one technikon as important skills

The course which was augmented in style included

*the importance of qualitative and quantitative analysis; hence standardisation and gravimetric techniques were included.

Five technikons agreed that techniques taught in the bridging course are directly linked to those taught in higher levels and obviously the three technikons which have bridging students as part of the mainstream answered that the subject matter was the same.

Comments

The need for appropriate laboratory activities for students is reaffirmed by Hofstein (1988):

> Appropriate laboratory activities can be effective in promoting logical development and some inquiry and problem solving skills. They can assist in the development of manipulative and observational skills and in understanding scientific concepts. They can also promote positive attitudes, and they provide opportunities for student success and foster the development of skills in cooperation and communication. Science laboratories

> should enable students to use information, to develop a general concept, to determine a new problem, to explain an observation and to make decisions (in Australian Journal of Chemistry, no 41 of 1996:212).

Question 30.1 and 30.2 and 30.3

Is there a pre-prac talk before each practical session?

How much time does this involve?

Is a demonstration considered necessary as well?

Responses

All eight technikons conduct a talk before the session and the time involved varies from 5 minutes to as much as 30 minutes for a pre-prac talk. Seven technikons deem it necessary to demonstrate as well, but one does not.

Comments

It is felt at Mangosuthu Technikon that pre-prac talks are beneficial to students and lecturers alike. It is the time when the practical, possible problems and safety features are discussed. Further planning is carried out and interaction is possible between the lecturer and students.

> On all the evidence, the prelab exercise in which students read, planned, calculated and reported in advance was clearly beneficial ... understanding was enhanced (Johnstone et al, 1994:84).

Question 31:

Are all practicals "foolproof", i.e. cannot fail?

Responses

Three technikons stated that the practicals in their courses are "foolproof" (cannot fail) yet five technikons did not have such practicals.

Comments

It has been widely documented that science practicals should be challenging since, if outcomes are known in advance, the element of surprise would be eliminated. Mitchell and de Jong (1994) write:

> student input into 'fuzzy' [i.e. where there is no exactly right answer] practical work is valued by them above recipe-style practical work where they can get the right answers if they are clever enough irrespective of the actual data accumulated" (in Higher Education Research and Development, Vol. 13 of 1994:177).

However work for bridging course students cannot be too difficult to understand or carry out either, as that would not induce interest. The course under analysis is a bridging course attempting to redress poor secondary tuition so practicals cannot be too cognitively challenging, as most students are being exposed to proper tuition for the first time.

Question 32:

Are practicals designed:

to illustrate scientific facts the students are aware of?

to provoke students into asking questions about new issues in science?

Responses

Eight technikons agreed their practicals are designed to illustrate scientific facts the students are aware of. One technikon added that the practicals were also designed to provoke students into asking questions about new issues in science, as well as to illustrate facts.

Comments

The practicals at this particular bridging course level merely emphasise "Piaget's contention that active participation is essential for learning to take place" (Variety in Chemistry Teaching, 1996:25). The integration of practical work into an education course for bridging course students is a new and exciting part of their development. The shift in emphasis from, "teaching to learning, so that students take more command of the process of active learning, discovery and creative enquiry" (Variety in Chemistry Teaching, 1996:9) should be a priority for this type of bridging course.

SECTION E

This section of the questionnaire deals with assessment, which is a contentious issue according to the literature available:

> Since one can fairly equate what is deemed to be educationally worthwhile with what is assessed, it is, therefore, surprising, perhaps even embarrassing, that practical science is traditionally unassessed (Bryce et al, 1987:10).

Boud et al stress the value of assessment. The emphasis of their convictions consists in two pointers:

> the need to provide students with indications of the extent to which they are meeting the aims of the laboratory course, and how they can improve on their performances. This is assessment for feedback, and is an essential component of the teaching-learning process and for grading purposes. Both forms of assessment are necessary features of a balanced scheme (Boud et al, 1986:79)

Question 33:

Are students assessed during the practical sessions?

Responses

Five technikons assess students during practicals. Three technikons do not.

Comments

It is encouraging to note that the majority of technikons assess students during practicals, since

> Prac work involves abilities, both manual and intellectual which are in some measure distinct from those used in non-prac work (Giddings and Hofstein, 1980:57).

Students will realise the importance of practical work if they are not only continually monitored but also corrected and guided throughout a practical session. It would appear that this would enhance the learning process as, according to Hegarty-Hazel, "the learner is an active processor" and that "understanding cannot be taught but can be created by the learner from experiences directed by the teacher" (Hegarty-Hazel, 1990:167). Hegarty-Hazel is supported by Boud and Dunn:

> Feedback is crucial to student learning and progress (Boud et al, 1986:80).

Question 34:

Are students assessed on reports written by them?

Responses

Six technikons assess students on reports written by them. One technikon assesses students only at the end of the course while another technikon does not assess reports.

Comments

According to Giddings and Hofstein, the three methods of evaluation [available to] the Science teacher are:

> *written evidence
> *one or more practical examinations
> *continuous assessments (Giddings and Hofstein, 1980:58)

Reports form an important part of communication skills which are becoming increasingly more in demand not only from lecturers but from industry as well. Gerrans et al (1991) write that, "report writing assists students by actively increasing their knowledge of the subject when preparing a laboratory report" (Gerrans et al, 1991:40). Chemistry graduates are being prepared for a wide range of future careers and potential employers are placing more importance on oral, written and computer literacy skills which emphasises the need for such skills as report-writing to be encouraged and enhanced in foundation courses.

Laboratory reports "can contribute significantly to students' understanding of chemical concepts" according to Garnett and O'Loughlin (1989), who also write that "reports are useful in that they encourage careful analysis and interpretation of results and the drawing of conclusions" (Garnett and O'Loughlin, 1989:29).

One Chemistry department involved with assessing chemistry students (in England) suggest a comment book for recording comments about the "performance of an experiment by any individual student" (Meester and Maskill, 1993:158). These comments can be included as part of the final mark of that experiment (after Meester and Maskill, 1993).

Question 35:

When is assessed work marked and returned to the students?

Responses

Generally, all students receive their assessed work within 1week (i.e. five technikons do this). One technikon hands back written work after 3 days and yet another signs each set of results but then the books are taken in at the end of the course and a mark is allocated to each practical officially.

Comments

Timeous correction and guidance are imperative to these students, who are learning new skills daily.

> Promptness - it is of little value if feedback is provided after the student has completed the work and is engaged in new activities. Feedback is usually most effective directly after the work has been completed (Boud et al, 1986:82).

Question 36 and Question 37:

What criteria is the assessment of the written reports based on?

Please describe very briefly the way in which judgements are made on the quality of the students' practical work?

Question 36 Responses

According to most of the technikons the main criteria for the assessment of the written reports are accuracy, clarity of observation, understanding of concepts and presentation.

Comments

This are acceptable criteria, since assessors make judgements and comments "directed towards matters which are within the student's power to tackle" (Boud et al, 1986:82).

Question 37 Responses

The way in which judgements are made on the quality of a student's practical ability is, in the case of four technikons, a case of comparing student results to known results; one technikon actually assesses the efficiency with which the student makes use of the equipment while one technikon makes use of a specific computer programme for judging the quality of students' work. There does appear to be an attempt (albeit it a limited one) at devising fresh ideas for the assessment of bridging course students. One technikon merely answered that assessment is carried out through tests and examinations.

Comments

> This process of allocating a grade to a student is a shorthand method of summarizing the quality of student achievement (Boud et al, 1986:82).

Question 38:

Are students' practical assessment results incorporated into a course mark or are they quoted independently?

Responses

Only one technikon quotes practical assessment results independently; the others incorporate the practical result into the course mark.

Comments

The commitment to the importance of practical work is evident in most of the technikons' responses,but practical work has yet to reach such importance that it is quoted independently. One technikon is doing this and one would hope it becomes a trend. It is the writer's opinion that the use of practical tests (where the mastering of various skills would be tested), together with laboratory reports, would emphasise to students the importance of laboratory work. The need for commitment from the student would be encouraged.

Question 39:

If incorporated with other marks please indicate how?

Responses

These responses were somewhat varied but overall technikons show commitment to ensuring that practicals are taken seriously by incorporating the marks into the year mark.

One technikon incorporates the practical marks into a "test" mark and these "test" marks plus theory tests are included in the year mark. The final examination is a theory paper and a practical paper, and these marks are then added together with the year mark in the ratio 40:60 for the final mark. Another technikon incorporates the practical mark as 10% of the year mark and this is 40% of the examination mark. Two other technikons incorporate the practical mark as 30% of the final mark. One technikon ensures that practical and theory marks are equally weighted for the final mark. One technikon incorporates the practicals as 10% (Chemistry) and 20% (Physics) of the year mark. One technikon answered that practical tests count 20% of the class mark and the practical examination 20% of the examination mark.

Question 40:

Must students pass the practical component in order to pass the:

Chemistry course?

Physics course?

Entire course?

Not applicable (a practical course need not be passed)?

Responses

One technikon replied that the practical component had to be passed in order to pass the Chemistry course. Two other technikons replied that the practical component had to be passed in order to pass the Chemistry and Physics courses. Only two technikons needed the practical component to be passed in order that the entire course be passed. Two technikons answered that the practical course need not be passed. (The final answer was that it was incorporated into the examination mark and 40% was required in the examination to effect a pass).

Comments

These responses demonstrate that institutions are committed to ensuring students are trained as technicians (i.e. are competent in practical skills and have sufficient theoretical knowledge to be able to cope with the demands (ultimately) of industry). Theoretical knowledge is insufficient for a chemical technician. The aims and objectives of tertiary institutions as set out by the Department of National Education and stated in the National Education Policy are clear on this issue: **"Tertiary institutions must prepare people for a particular occupation or industry and are orientated towards the practice, promotion and transfer of technology" (NATED 02-150 94/01:vii).**

Question 41:

What kind of media do you make significant use of in the practical class?

Chalkboard/overhead projectors/slides/audiotape/film/videotape/posters/models/computer

Responses

Seven technikons replied to this question. All seven made use of a chalkboard. Three made use of OHPs, one made use of film and/or videotape, two made use of posters and one used models to demonstrate concepts to the students. Five technikons made use of more than one kind of medium in the practical class which demonstrates a commitment by staff to enhancing the learning process for students.

Comments

Laboratory work offers a change from other modes of learning and it is here that the students can be fully active. It was shown earlier that variety in teaching is effective and that it stimulates students' interests. The use of differing media in addition to laboratory work will enhance students' learning environments and encourage them in their studies.

Question 42 and Question 44:

In your opinion does the practical work have an effect on students' success at the formal level?

In your observation is the bridging course a success?

Responses

With only one exception it was agreed that practical work has an effect on students' successes at the formal level and the same seven respondents declared that in their observations their bridging courses were successful.

Comments

Practical work should be an integral part of the science curriculum which mirrors, reinforces and augments the rest of the course (after Gott and Duggan, 1995). This shows clearly that, if it is an integral part of the course, practical work will have an effect on a student's ultimate success.

The following extract underlines the importance of practical work in the future development of a learner:

> Gardner has identified a four-stage pyramid of learning in which KNOWLEDGE forms the lowest, foundation layer. From knowledge the learner gains TECHNIQUE (layer 2). The learner practices until he or she has sufficient fluency or expertise for the technique to be classed as a SKILL(layer 3) by which competence in that area can be demonstrated. Application of analytical thought and polishing of skills, leads ultimately, to attainment of the uppermost layer, where the learner can be said to possess an ART (Ottewill and Walsh, 1997:1426).

Question 43:

How is the overall success of the bridging course determined?

Responses

Five of the technikons agreed that overall success is determined by the number of students who progress to formal education and the acquisition of a tertiary qualification. One technikon determines success by the pass rate of students who pass all subjects, as well as by feedback from the Chemistry department concerning the quality of Pre-Technician students in the formal section.

Two technikons did not answer.

Comments

One of the technikons which did not respond to Question 43 has, however, had some work done previously on the assessment of its bridging course. Note the results achieved by this technikon, where the success rate has been determined by the number of students selected for mainstream expressed as a percentage of the total number of students in the bridging course programme:

Course - semesterised (2 per year)	Students	Accepted	%
1	11	7	64
2	38	15	39
3	21	13	62
4	46	35	76
5	54	34	63
6	83	41	49
7	64	38	59
Total	**317**	**138**	**58**

(Sharwood, 1993:5).

After each course, except course 6, more than half the students who had enrolled as Pre-Technicians were successful and accepted into the "mainstream" course. These results indicate some success for the courses in the sense that many students who would before have been unable to enter tertiary studies have, through the Pre-Technician course, gained the reward of being admitted to such studies (after Sharwood, 1993).

Question 45

Will the bridging course continue for?

another 2 years?

between 2 and 5 years?

between 5 and 10 years?

more than 10 years?

Responses

Opinions were varied regarding the period of time bridging courses would continue to fulfill a need. One respondent was noncommittal (unknown). Two respondents felt that the bridging course would continue for another two years, while two stated that they thought between 2 and

5 years would be the case. Only one response suggested between 5 and 10 years and two felt that more than 10 years would be necessary.

SECTION F

According to Sharwood (1993) "continuous evaluation is absolutely necessary to develop a truly effective bridging programme" (Sharwood, 1993:5). It is hoped that more technikons will undertake to assess their bridging courses, collect data and statistics, analyse and evaluate and to thus work towards a course which will ensure success for the students. Five technikons provided limited statistics. Only one technikon had separate figures for the number of students who passed the practical component. The statistics submitted are tabulated below.

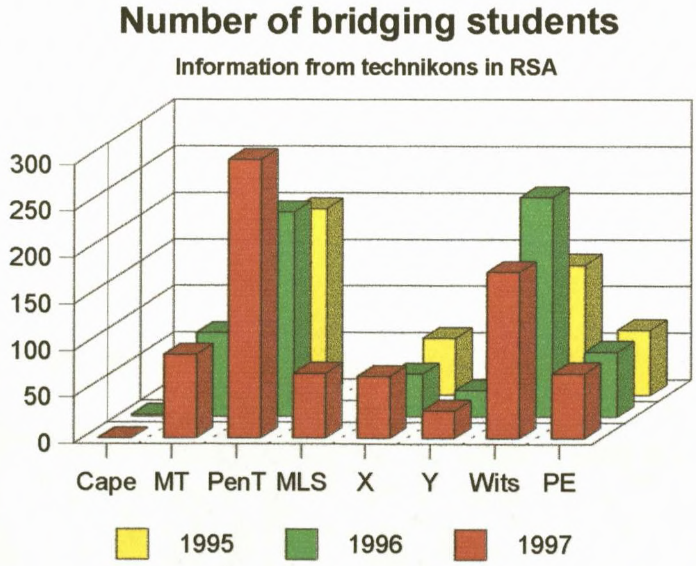
Question 46:

The number of students registered for the bridging course:

Year	Cape	MT	PenT	MLS	X	Y	Wits	PE	**Total**
1995	5	120	200		61	28	140	70	**624**
1996	2	90	220		46	28	236	70	**692**
1997	0	90	300	70	67	30	179	70	**806**

(This shows merely the differences in the numbers of students who enrol for bridging courses at different technikons).

Figure 10: Pre-Technicians - Number of bridging students (1995 - 1997)



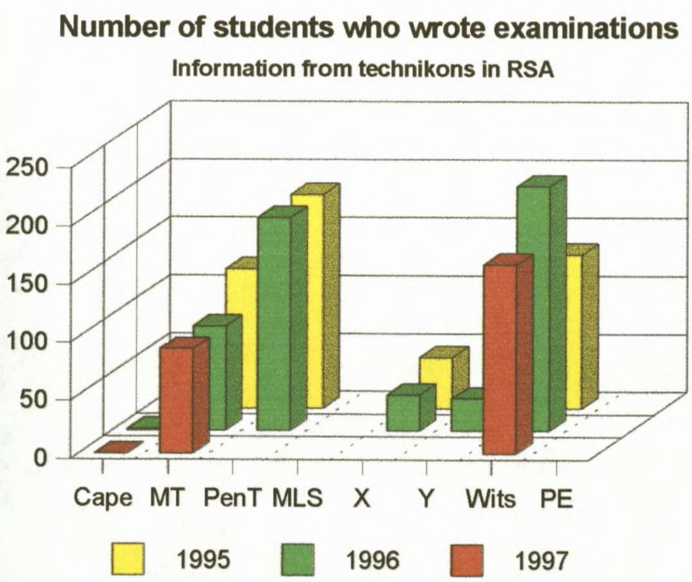
Question 47:

The number of students who wrote final examinations

The figures differ a little from the number of students who initially registered for the bridging courses, which could be due to factors such as absenteeism, poor marks during the course, illness or a decision after counselling to do something else. The results are graphically depicted for comparison with the number of students who enrolled (see Question 46) and who passed (see Question 48). (Blank spaces indicate that no information was provided).

Year	Cape	MT	PenT	MLS	X	Y	Wits	PE	Total
1995	3	120	184		44	28	133		512
1996	2	90	184		31	28	211		546
1997	0	90					163		253

Figure 11: Pre-Technicians-Number of bridging students who wrote the examinations (1995-1997)



These figures indicate that some students initially enrolled for the course but for one or other reason did not write the final examinations.

Question 48:

A: The number of students who passed

Yr	Cape	MT	PenT	MLS	X	Y	Wits	PE	Total
95	1	80	129	no info	5	23	95	no info	333
96	1	45	147	no info	5	21	141	no info	360
97	0	50	110	no info	no info	no info	78	no info	238

The above information expressed as % of examination entrants:

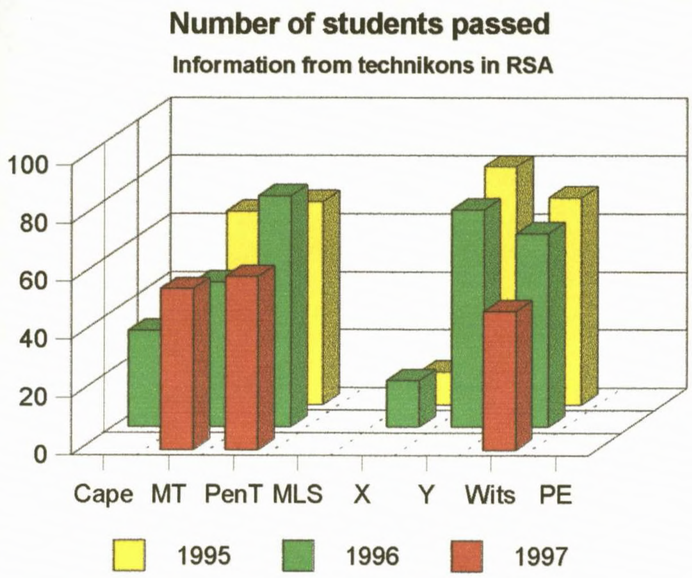
Year	Cape	MT	PenT	MLS	X	Y	Wits	PE
1995	33.3	66.7	70.1	No info	11.4	82.1	71.4	No info
1996	33.3	50.0	79.9	No info	16.1	75.0	66.8	No info
1997	No info	55.6	59.8	No info	No info	No info	47.8	No info

Comments

The number of students who pass the bridging course ranges between 40% and 80% of the total number of students who wrote the final examinations. The students who have thereby gained entrance to the formal course have been brought to tertiary education as a direct result of bridging courses. Generally, the results submitted by the technikons reflect a satisfactory pass rate.

Figure 12: Number of bridging students who passed (1995 - 1997)

In previous research carried out by the writer it was found that "of the 100 students in our research sample 75 progressed to T1 level. This clearly indicates the relevance of the Bridging Course in that it has enabled a majority of students to enter into the recognised tertiary Diploma course and achieve success therein" (Lafferty & O'Brien, 1994:2).

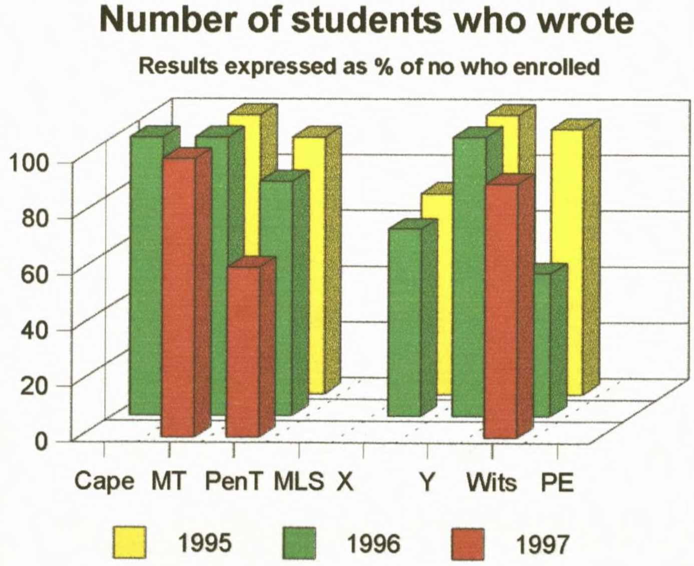


Question 48

B: The number of students who wrote the final examinations expressed as % of the number of students who originally enrolled

Yr	Cape	MT	PenT	MLS	X	Y	Wits	PE
1995	60	100	92		72	100	95	
1996	100	100	84		67	100	51	
1997		100	61				91	

Figure 13:B Number of students who wrote final examinations (1995 - 1997)



Comments

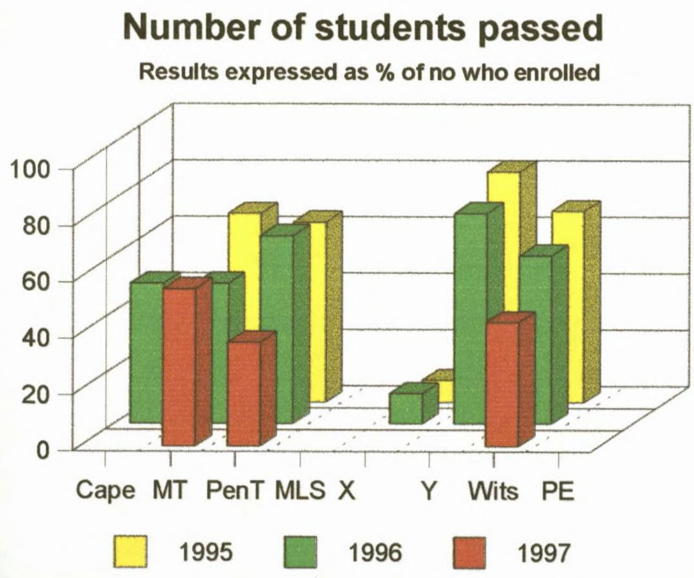
It would appear that two technikons allow the full complement of students enrolled to write the examinations. It would appear that other technikons do not have the same population writing as that which was enrolled. Circumstances such as poor course rate and students leaving the course would result in these two figures not being similar.

Question 48

C: The number of students who passed expressed as a % of the number of students who originally enrolled

Yr	Cape	MT	PenT	MLS	X	Y	Wits	PE
1995	20	67	64		8	82	68	
1996	50	50	67		11	75	60	
1997		56	37				44	

Figure 13:C Number of students who passed (as % of number who enrolled) (1995 - 1997)



Comments

From the limited statistics available there appears to be an average pass rate (expressed as % of total no enrolled) of approx 60% to 70% among the technikons.

Question 49:

The number of students who passed practicals:

Responses

Unfortunately only Mangosuthu Technikon supplied statistics for this question. The writer has collected data pertaining to this question and for many other relevant concerns from Mangosuthu Technikon.

Comments

An in-depth analysis of such results will be taken up after this resume is complete (see Chapter Seven).

Question 50:

Of those students who were successful in the bridging course, how many registered for and were successful at S1 level?

Responses

Five technikons responded, but with limited statistics. The responses are presented here as percentage success (Pass) of those who enrolled in S1.

Year	Cape	MT	PenT	MLS	X	Y	Wits	PE
1995 sem 1	20%	70%	no info	no info	100%	20%	88%	no info
1995 sem 2	50%	74%	no info	no info	100%	50%	85%	no info
1996 sem 1	100%	50%	no info	no info	100%	100%	86%	no info
1996 sem 2	100%	55%	no info	no info	100%	100%	56%	no info
1997 sem 1	no info	no info	no info	no info	no info	no info	94%	no info

It is quite clear from even the limited statistics supplied that S1 students who successfully complete the bridging course have a strong likelihood of success at the S1 level. Mangosuthu Technikon students who were successful at the Pre-Technician course have on average had at least 50% success at the S1 level. In other data collected and analysed by the writer the following has been recorded:

Of the 75 students who had successfully completed the Bridging Course and progressed to T1 level, 62 students were successful in their first attempt at T1 level (i.e. 83%), 12 students were successful in the second attempt at T1 level, and 1 student was successful in the third attempt at T1 level (Lafferty & O'Brien, 1994:2). This supports the figures presented above.

In support of this data the writer has ascertained that, of the 45 Analytical Chemistry students who passed the Access course in 1994 and went on to S1, 31 were successful at S1 level (i.e. 69%). Of the 50 chemical engineering students who passed the Access course and progressed to S1 level, 40 were successful (i.e. 80%).

Another technikon, which did not submit any data, has previously (as stated earlier) had assessment work done concerning its bridging course. The success of its students who enter mainstream has been determined thus:

> **... Evaluation during Mainstream studies**
>
> **Credit Ratio**
>
> **Credit Ratio = Number of Credits/number of subjects taken**
>
> This is very easy to calculate and is a good indicator of how bridging students compare with selected students in mainstream studies. It is very meaningful in the first year but after that it becomes a bit complicated as some of the students fail and drop out while others may repeat subjects.
>
> Before the Academic Support Programme was introduced and a careful look was taken at our selection procedure the following results were being obtained in the first level examinations.

Group	Credit Ratio
White	58%
African	26%

A longitudinal study provides the following:

Attendance in mainstream	**Pre-Technician Students (Credit ratio)**	**Pre-Technician students (n)**	**Selected students Credit ratio**
1st attendance	78%	71	75%
2nd attendance	78%	26	75%
3rd attendance	78%	12	86%

There is a considerable improvement in the pre-technician results as they are mainly African and the spin off with the better selection system is the improvement in the selected student's results

... the pre-technician cohort achieved higher marks in three of the five subjects taken (Sharwood, 1993:5).

Another technikon which did not answer this particular question also reported some limited statistics in 1990:

> This particular bridging course allows students to attempt the normal course subjects over an extended period of two semesters. The cohort who went through this bridging course in 1989 performed well, i.e., a 76% pass rate in Mathematics 1 compared with a 67.4% pass rate by students in the regular course. A 60% pass rate in Chemometrics 1 compared with a 56.8% pass rate by students in the regular course. The following semester's results were satisfactory in comparison with the regular course - i.e., one out of three subject pass rate for bridging course students which was higher than the normal course pass rate. These students then entered their third semester but were effectively in the second semester of the regular course and once again their pass rates in their various subjects were better than those students in the regular course - i.e., four out of five subjects indicated a pass rate equal to or better than the regular course (Fester, Gihwala, Sadeck, 1990:2).

Question 51 and Question 52:

Has a survey been conducted regarding the effect of the bridging course on the formal level S1?

Has a survey been conducted regarding the effect of bridging course practical work on the formal level S1?

Responses

Only two technikons have conducted surveys on the effect of the bridging course on the formal level S1 and only one has conducted a survey regarding the effect of the bridging course practical work on the formal level S1 (these results appear in Chapter Seven).

Comments

It is precisely this factor that encouraged the writer to undertake this study in an effort to determine the effectiveness of the bridging course and in particular the practical bridging course. Such courses should be constantly evaluated and redesigned to achieve maximum benefit to students.

Question 53.1:

Were the S1 students who originated from the bridging course able to recognise glassware for the practicals?

With ease?

With a little assistance?

With a lot of assistance?

Responses

Three technikons agreed that students from the bridging course were able to recognise glassware for the practicals with ease; one technikon said that such students required a little assistance to do this and, interestingly, the technikon whose students are from the augmented programme (thereby forming a part of the mainstream) answered that such students needed much assistance in this regard, which confirms that normal school leavers have little or no practical experience and require assistance such as a bridging course would give. The sixth technikon remarked merely that students were part of the formal course anyway (they do only three subjects in the first semester). Two technikons failed to answer.

Comments

This question was also put to lecturers at Mangosuthu Technikon to determine their responses. These were discussed in Chapter 1.

Question 53.2:

Were these students able to carry out the initial S1 practicals

With ease?

With a little assistance?

With a lot of assistance?

Responses

Two technikons agreed that bridging course students were able to carry out S1 practicals with ease and three technikons stated that the students could do this with a little assistance. The sixth technikon remarked that students were part of mainstream anyway (see Question 53.1) and two technikons failed to answer.

Question 53.3:

In your observation, how do students with bridging course experience cope with practicals compared with those students who enter S1 directly from school?

Responses

Three technikons agreed that bridging course students coped better with practicals than those students entering S1 directly. A report on a visit to Border Technikon repeats that finding as do the responses from lecturers at Mangosuthu Technikon (results quoted in Chapter One). Two technikons (one of whom has students as part of an augmented programme) felt there was little difference and the sixth technikon stated that students were part of the formal S1 level (see Question 53.1). Another technikon, who did not submit data has, as previously noted, carried out some assessment work on its particular bridging course, and when a subject achievement comparison was carried out between students (in S1 level) who had been through the Pre-Technician course and selected students who went directly into mainstream, it was found that:

> 92% of the Pre-Technician students passed the Chemistry 1 course whereas only 87% of the selected students were successful. The selected students however did obtain 63% overall average as opposed to the 59% achieved by the pre-technician group of students (Sharwood, 1993:9)

Students who were successful at the Pre-Technician course level performed better at S1 level than those students who were admitted directly into the formal course).

Question 54.1 and 54.2 and 54.3 and 54.4:

Have students been questioned regarding the worth of the bridging course?

If YES, have the responses been favourable?

If favourable, please give brief examples of some such responses

If unfavourable, please give brief examples of some such responses

Responses

Four technikons answered that students had been questioned regarding the worth of the bridging course or, where relevant, of the extended course. One technikon had not done so and the remainder did not respond. All four technikons who had questioned students reported favourable replies. One technikon included in the response section that "students would not have been able to study at University without bridging and found the Personal Leadership and Learning Course very helpful". Another technikon said that "students have confidence that their bridging course assists in technikon work as some of the topics have been covered". An unfavourable response was that "there is far too much spoon-feeding [in the bridging course] and they find this lacking in mainstream". One other technikon commented that students felt all students should do a Pre-Technician course. Five technikons did not respond.

It would be appropriate at this point for the writer to add the following information, relevant to Question 53 and Question 54. A small group of the Mangosuthu Technikon Access students who had been successful with the Access course (i.e. the general bridging course with no practical work for the students) in 1994, and promoted to S1 were asked by the author how they had coped with the practical work at S1 level.

Of those questioned (as stated in Chapter One) 70% said that they had coped with some difficulty and 30% with much difficulty. Not one student claimed to have coped easily. They felt at a disadvantage having not had practical work integrated into their study course.

> ...when we do practicals it was too difficult because we didn't know what to do. We didn't even know the functions of the glassware and other equipment (verbal report by a 1994 Access student).

The students from the previous Pre-Technician course prior to 1994, (i.e. the course which included practicals), however, answered quite differently:

> On reaching S1 from pre-tech I was familiar and used to the laboratory work which made work a bit easier *and* The practicals help you right through to the industry and As I reached S1 from Pre-Tech I already had a good foundation (in Lafferty, 1995:2).

5.2 CONCLUSION

All the information in this chapter, despite the limited statistics, seems to indicate that bridging courses are necessary and that practical work is important to such a course. The technikons which responded are committed to the success of bridging courses, as are staff involved with such courses and educationally disadvantaged students in such courses.

5.3 REPORT ON INTERVIEWS AT TWO TECHNIKONS

BT: BORDER TECHNIKON 7/10/97

TWR: WITWATERSRAND TECHNIKON 8/10/97

5.3.1 THE TASKS SHEET AND INTERVIEW STRUCTURE

5.3.1.1 MEET WITH STAFF

5.3.1.1.1 Interview staff involved with the bridging programmes

5.3.1.1.2 Explain the purpose of the visit

5.3.1.1.3 Follow up on anything outstanding from the questionnaires

In particular: obtain records of matric results and, if any, the comparisons of the matric results with final bridging course results (as answered in the questionnaire, question 3.1 and 3.2).

5.3.1.1.4 Obtain: copies of the practical manuals

to look at sequence of practicals, their contents and their objectives.

Copies of practical tests and mark schemes. Statistics, where possible, of bridging course students and their follow-on results at the higher formal levels.

5.3.1.1.5 General: discuss any common problems or concerns regarding the present course, with particular emphasis on the practical aspect

5.3.1.2 Meet with current bridging course students and record observations during a practical session

5.3.1.2.1 Observations:

5.3.1.2.1.1 The duration of the pre-practical talk

5.3.1.2.1.2 When and where demos are done for each practical

5.3.1.2.1.3 Whether students participate in the pre-practical talk

5.3.1.2.1.4 Whether students are prepared for the practical they are about to participate in

5.3.1.2.1.5 Whether students work individually or in larger groups and if so why?

5.3.1.2.1.6 Whether the laboratories are technique-centred rather than lecture orientated

5.3.1.2.1.7 Whether students are comfortable with the glassware usage

5.3.1.2.1.8 Whether they appear to be interested in the particular prac

5.3.1.2.1.9 Note the attitude to the practical work?

5.3.1.2.1.10 Whether locker/glassware is available for student use

5.3.1.2.1.11 Whether the laboratory space is adequate

5.3.1.2.1.12 Whether students take practical work seriously and why?

5.3.1.2.1.13 Whether the lab period is divided into a skill learning period (in which skills are explicitly taught) followed by a period in which students will use their skills in a prescribed situation thus gaining experience of skills taught?

(To read a detailed interview sheet see Appendix 10)

Border Technikon:

The writer met with Barry Chapman (Head of Tertiary Foundation Course - TFC) and James Valiathazhel (Lecturer for TFC). The course which is practically orientated focuses on practical procedures in Physical Science. "So many of our students in this area come through school systems sorely lacking in either adequate physical science training or laboratory facilities" (Chapman in F&T Weekly, 25 April 1997). The two interviewees were presented with a letter of introduction and conversation took place about the purpose of the interview.

Unfortunately there were no records of matric results for comparison to TFC results. Mr Valiathazhel supplied the writer with a copy of the practical schedule as well as the end-of-year practical test. Unfortunately no other statistics concerning the success or otherwise of the bridging course were available. Both lecturers were quite adamant that a bridging course of this nature was still needed as the schooling system had not improved a great deal. In fact some students accepted onto the course had Matric symbols as low as GG for Physical Science and Mathematics. Schools were still not very active in practical work. Both lecturers were positive about the success of the course and recalled positive feedback from students as well as formal course lecturers. The bridging course feeds several formal courses and is not specific to one discipline

Pre-practical talks were approximately 15 minutes but none were held on the day of the interview as that day's practical work was a revision session. Students participated in the pre-practical talk on a question and answer basis which was led by the lecturer. Students felt that pre-practical talks were beneficial as it ensured their focus was correct. A demonstration of the day's practical session took place on the front bench so all students could see the lecturer and be involved in the demonstration. Students were prepared for each practical. They set up and prepared the practicals, using previous theory lecture notes and understanding.

There were two students in each practical group. Students were supplied with locker kits which were more than adequate for practicals. The laboratory was large, clean and in good condition, with adequate space, but perhaps suitable ventilation needed to be addressed. The laboratories were technique-centred, which emphasises the need to develop hands-on experience since that is the area students have been disadvantaged in. The students appeared to be very comfortable with the glassware and other hardware they were making use of. Training throughout the course had ensured that they were able to use the laboratory equipment with relative ease and minimal assistance, ensuring they would cope better in the formal course, after much experience. The students appeared to be very interested in the practical session and exhibited positive attitudes to the practical work. Examinations were imminent, so practical work had become even more important and students took the practical work seriously. Marks obtained from practical work played a significant part in their final marks, which ensured they realised the importance of such tuition.

According to the lecturer the laboratory period is divided into a skill learning period (in which skills are explicitly taught) followed by a period in which students will use their skills in a prescribed situation thus gaining experience of skills taught. Obviously, for the observed recapitulation session this was not the case. The skills had already been taught but were being refined.

Witwatersrand Technikon:

Unfortunately the visit to the Witwatersrand Technikon was not nearly as organised (compared with the visit to Border Technikon) in terms of availability of lecturers and students for interviews. The writer met with the Laboratory lecturer Ms Louise McKechnie and a lecturer (Louize Lindeque) from the formal course (S1 Chemistry students). The letter of introduction was given to the interviewee. Unfortunately there were no records of matric results. The practical handouts were made available but, statistics concerning the success or otherwise of the bridging course were not available. The two lecturers involved with the bridging course expressed mixed feelings about it's success. One was adamant that practicals had a positive effect on students and that if they understood practically it assisted with the theoretical understanding. The second lecturer, however, felt that because the bridging course was not focused on Analytical Chemistry (general course for technicians) the students still needed much guidance practically on reaching the formal course. (This is understandable, in that only four practical chemistry sessions had been held in that particular semester, which is hardly a quantity likely to be of much use).

The laboratory was large, clean and in good condition, with adequate space, but perhaps suitable ventilation needed to be addressed. Students were supplied with locker kits which were more than adequate for practicals. Approximately 15 minute pre-practical talks took place before each practical and this was the case on that day. It was disappointingly not well constructed. Other instructions were delivered during the session. Students felt that it was beneficial as it ensured their focus was correct. Students stated that pre-practical talks were beneficial in assisting with the objective of the practical. A demonstration of the practical was displayed on the front bench where the lecturer was clearly visible to the class but there was very little interaction between lecturer and students. The students read through the instructions and then continued with the practical work. Questions arose only during the practical. Students received the practical sheets/handouts on the day and were not prepared for the practical. The students worked individually as there were only twenty in the group. This group was specifically constituted for the Analytical Chemistry Diploma course. The laboratory session was technique-centred, to ensure that students from disadvantaged backgrounds received hands-on experience with laboratory equipment. It was those particular students' first time of involvement with the particular glassware so they needed much assistance. That again emphasised the need for extensive training for those students before they reached the formal courses, where they were expected to recognise the laboratory equipment and handle it correctly, with minimal assistance. The students showed interest in the practical session but because of the instructions being delivered simultaneously, were unable to concentrate clearly on each task at hand. The students were positive about practical work and the lecturers stated that students attended practical sessions even though they do not have to pass the practical to complete the course. The students realised the practical had been specifically designed to assist their learning needs and reinforce theory. The laboratory period was divided into skills learning period followed by a period in which they used those skills in a prescribed situation thus gaining experience of the skills learnt.

In the observed session the students learnt how to titrate and were then asked to use those skills in completing a practical exercise.

5.3.2 STUDENT PROFILE:

Group A (in practical class)

No of students present: 12

Previous practical experience:

No practicals at school	Very few practicals and almost no hands-on experience	Some practical experience but mainly teacher demonstration	Did have practicals	Total
8	1	2	1	**12**

Group B (who were attending lectures during the corresponding time period)

No of students present: 17

Previous practical experience:

No practicals at school	Very few practicals and almost no hands-on experience	Some practical experience but mainly teacher demonstration	Did have practicals	Total
5	3	9	nil	**17**

MATRIC GRADES

Physical Science:

HG	SG
C:1 D:0 E:3 F:3 G:2	C:0 D:0 E:3 F:4 G:0 H:1
Total:9	**Total:8**

Mathematics

HG	SG
	D:2 E:5 F:10
	Total: 17

Of the seventeen students, three were still achieving only an E for these two subjects, in the Tertiary Foundation Course, whereas the balance of the students were obtaining D and higher.

The writer also questioned the student who had obtained a C in HG for Physical Science about the worth of the course to her. She praised the course and stated that the practicals linked to theory were of substantial benefit to her.

5.3.3 INTERVIEWS WITH CURRENT STUDENTS

5.3.3.1 Are students prepared for the practical they are about to participate in?

5.3.3.2 Are students given learning objectives for the practical?

5.3.3.3 How many hours do students spend on preparing (if any)?

5.3.3.4 Is a pre-practical talk beneficial?

If YES, why?/If NO, why?

5.3.3.5 What could the student recognise in terms of glassware and other laboratory facilities when beginning the course?

5.3.3.6 What could the student do in a laboratory when first attending?

5.3.3.7 Do students prefer working as currently arranged (i.e. individually or larger groupings whichever is the case), or not?

5.3.3.8 Which arrangement is preferable and why?

5.3.3.9 Do students regard practicals as an integral part of their chemistry and/or physics course?

5.3.3.10 Are the practicals linked to their theory (their perceptions)?

5.3.3.11 How many hours do students spend on report writing/presentation of data (whichever is required)?

5.3.3.12 Would students like a feedback session regarding mistakes, reports and marking? (And why?)

5.3.3.13 Which is preferable for reporting - sheets for data presentation or completion of a full report write-up?

5.3.3.14 Are students looking forward to the formal course and in particular practical work?

5.3.3.15 Would students like to visit industry to see practical work in real life?

5.3.3.16 Has the course been beneficial to them, and why?

5.3.3.17 What (if any) changes would they like to see concerning the bridging course and in particular the practical work (eg. recognition of the course):

5.3.3.18 Would students like to evaluate the practical course when the semester ends?

(To read a detailed interview sheet see Appendix 13)

Students at both technikons were given general objectives from which they had to extract a particular aim for the practical in question. Students at Border Technikon when questioned about the time they spent preparing for a practical answered that they generally spent between 15 and 30 minutes preparing. The students at Technikon Witwatersrand stated that no preparation work had been done. The majority of students at both technikons had very little laboratory experience. They stated that they recognised very little glassware when beginning the course. Most of the students also agreed that they could do very little in terms of laboratory work when they started the course. Some students at Border Technikon enjoyed working in pairs while others would at Technikon Witwatersrand were pleased to have their own lockers and to be able to work individually because it was different from the overcrowded conditions they had been used to at secondary school. Students at the two technikons were emphatic in their positive response with regard to practicals being an integral part of their Chemistry and/or Physics course. The students at Border Technikon believed their practicals to be directly linked with the theory whereas students at Technikon Witwatersrand perceived it to be only partially so. Not much time was spent on practical report writing at both technikons. All students interviewed were unanimous that they were looking forward to the formal course and the practical work. The bridging courses had helped to build up their confidence in the learning of science, and invaluable experience in practical work was obtained.

5.3.4 THANK PERSONNEL

All personnel involved with making the visit possible were thanked. All staff and students were thanked for their valuable input.

5.3.5 INTERVIEWS WITH PREVIOUS STUDENTS FROM TFC AND A MEMBER OF THE LABORATORY STAFF.

This section is applicable only to Border Technikon as the writer was unable to interview anyone else at TWR in full.

5.3.5.1 Interview with Tertiary Foundation Course students

The writer interviewed four past Tertiary Foundation Course (TFC) students now in the formal S1 Analytical Chemistry class:

All were positive about the benefits of attending the TFC course. They highlighted the practical experience gained and claimed also that the course provided a good introduction to campus life. The students declared that they had no problems during practicals in S1 as they were much more confident in the use of laboratory equipment as well as in taking part in practicals.

5.3.5.2 Interview with a current S5 student

The writer also interviewed a current S5 student who is doing experiential training on the campus.

He attended Thubulethu High School in Fort Beaufort where he was fortunate to have Science classes which involved much practical work and where students worked individually, although the more difficult practicals were run as teacher demonstrations. His Matric grade for Mathematics was D (HG) and for Physical Science E (SG). He had attended the TFC course, which he spoke highly of, and had enjoyed the practical work. He had been promoted after each semester. It would appear that his solid grounding in Physical Science at school and again in the TFC course has been most advantageous.

5.3.5.3 Interview with the Chemical Technician

The writer interviewed the Chemical Technician who was in charge of preparing the practical sessions in the Analytical Chemistry Department.

The technician reported that in a meeting two weeks previously the staff had noted that TFC students in the formal level S1 were coping better than those students directed from school. In his experience, he said, it was evident that TFC students coped better with practical work in the formal course than those who had not done the course.

CHAPTER SIX

THE REQUIREMENTS OF THE CHEMICAL INDUSTRY

6

6.1 INTRODUCTION

The political change in South Africa in the nineties has led to changes in education. It is clear, according to Gerrans (1996) that "South Africa has a crying need for a more technically trained workforce" (in Chemical Processing SA, January 1996:6). Bearing this in mind, it is encouraging to note that the most important change in Education is that curriculum development will no longer be strictly controlled by a central body but, rather by interested parties. Provincial departments of education and chemical industry, as well as NGOs, will be able to influence the development of relevant curricula. There are already some companies — eg ESKOM and MINTEK — who have initiated programmes within the company to assist with 'bridging the gap' and allowing greater access to knowledge through awareness of science and technology.

Gerrans (1996) confirms the importance of including industry's latest technologies, needs and demands in the teaching of science.

> The teaching of chemistry, without discussing aspects of the chemical industry, omits one of the most important features of modern life and, by implication, indicates that technological applications and developments are not important (in Chemical Processing SA, January 1996:6).

This section will consider the needs of industry regarding practical training of future technicians. Lindeque reports that now is the time for educators to "enter the world of the employer and the employee in the work situation". He reiterates that students are not equipped with the required job skills and asks that technikons take a "leading role in developing an integrated approach to education and training in South Africa" (Lindeque, 1993:6). The following section considers responses to a questionnaire administered to some companies in KwaZulu-Natal's chemical industry, aimed at the demands of industry vis-a-vis experiential trainees from the technikons.

A bridging course which is practically orientated would be a foundation to the formal courses which prepare an experiential trainee for work in industry. Not only would such a course equip students with the necessary skills required for academic success (thereby allowing more students access to mainstream studies at the institution), but the course would also enhance student employment opportunities and career aspirations. The chemical industry requires students to have had varied learning experiences. It also requires that students be involved in practical work which acts as a "vehicle for developing general skills" (Royal Society of Chemistry, 1992:3).

The Draft Policy on Education and Training (1994) strives to point out that as a result of the previous education system in South Africa there exist "huge inequalities in skills and competencies in the nation's labour force" (ANC, 1994:3). These inequalities need to be eradicated. Industry and the technikons could work together at solving this problem. Industry, however, appears to have little input into the practical tuition of technicians who are training at technikons. Data collected by the writer from the technikons and presented in a previous section confirms this. Only one tertiary institution confirmed that industry input influenced the planning of their practical courses. Industry supports technikons by making space available for experiential trainees. Industry should have some say in the practical tuition of these students. ICI (Britain) spokesperson John Monaghan (1992), confirmed his support for practical tuition when he reported that " industry would resist any diminution in the time spent on practical work". In his own words the practical training of a technician is important: "Practical skills should be the selling point, the added prize" (in Education in Chemistry, 1992:3).

The importance of linking industry to education in South Africa has resulted in several educational initiatives in which the chemical and allied industries are involved - eg ESKOM and MINTEK. The involvement of NGOs in chemical education has also been documented earlier, in Chapter One.

> But do chemistry graduates possess the skills that industry needs? a question from John Monaghan who was formerly an industrialist and now a professor at the University of Edinburgh, "the answer is largely no" (in Journal of Chemistry and Industry, October of 1997:752).

6.2 ANALYSIS OF RESPONSES TO QUESTIONNAIRE SENT TO INDUSTRY

Responses came from 13 companies which may be identified and one company, which answered only some questions, requested to remain anonymous.

1. **Company Names**

Van den Berg and Jurgens, SAPPI, Cooksons Chemicals, SMRI, Ivory Chemicals, SAPREF, Illovo, S&CI, AECI, Revertex, CG Smith, Blendcor and one other.

2. **Type of laboratory:**

Six companies stated that their laboratories were involved in Quality Control (QC). Four stated that the laboratories were of an analytical nature.

Two were specifically labelled organic laboratories and one boasts organic and inorganic laboratories. One company had three types of laboratories: QC, applications and development.

3. **Number of laboratory workers:**

VBJ 1	SAPPI 2	CC 3	SMRI 4	Ivory 5	SAPREF 6	Illovo 7	S&CI 8	AECI 9	Rev 10	CGS 11	Blend 12	Hulls 13	Anonymous 14
10	36	9	10	2	25	8	8	5	16	8	22	8	-

4. **Titles and responsibilities:**

These were common to most of the respondents. Laboratory Managers, Chemists, or QC Supervisors head up the laboratory team which commonly consists of Senior Analysts, Inprocess Analysts, Senior and Laboratory Technicians, Instrument Specialists, Research Officers, Samplers and Cleaners.

5. **Number of staff with a Tertiary Qualification:**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
6	7	2	5	1	10	2	No info	4	11	2	7	7	-

6. **Tertiary Institution from which staff qualified:**

Most of the companies have staff who qualified at KwaZulu-Natal technikons, as well as some staff who graduated from the two local universities. This confirms that technikons play a major role in the supply of technicians to industry.

7. **Is experiential training offered?**

Nine companies responded that experiential training is offered, two companies offer such training under certain conditions, and two do not offer training. One company failed to answer this question. It is encouraging that the majority of the local companies are keen to offer some sort of training for potential technicians.

8. **Did any present employees receive experiential training through the company?**

(The company requesting anonymity did not answer this question).

Eight employees received experiential training from the company they were working for. Four companies did not supply such training. One company did not answer this question.

9. **What are the required practical skills of experiential candidates?**

The responses were varied and ranged from less demanding skills, such as being familiar with wet chemistry (common to most companies), to differentiating between correct and incorrect techniques, general lab practices and skills, understanding of the uses of different equipment and glassware, good knowledge of wet chemistry, how to handle glassware, and the understanding of basic chemistry. The requirements then moved on to more challenging demands, such as: being able to apply skills and academic knowledge to the job being learnt, some knowledge of instrumentation and instrumental technique, knowledge of petro-chemical and related analysis, being able to interpret and evaluate results, the writing of reports when necessary, computer literacy and demands for an experiential trainee to be sufficiently motivated to tackle projects and have the ability to use sophisticated instrumentation.

10. **What are the qualifications and practical skills needed in a qualified technician?**

These requirements were obviously more advanced than those expected of an experiential trainee. One company did, however, state that they expected an experiential trainee and a qualified technician to possess the same skills. The requirements were, in general, varied but the most common skills demanded by industry were that an employee have a good knowledge of industrial laboratory work as well as wet chemistry and all basic techniques. Employees should also be able to operate analytical equipment and be able to follow instructions and work accordingly with minimal supervision (or, perhaps, a minimal training period on all new methods). Other requirements included quality and method auditing, method writing, precision and accuracy skills and, of course, investigative skills.

11. **In your opinion have the student experiential trainees had sufficient or insufficient "hands-on" experience?**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
yes	no	yes in '94 no now	no	no	yes in '94 no now	no	yes	no	yes	no	no	yes	no

It is clear that industry is not satisfied with the hands-on experience of experiential trainees. Interestingly two companies (Cooksons and SAPREF) which were approached by the writer in 1994 about the same concerns were satisfied with the experiential trainees at the time. However such views have changed.

Also of interest was the response from the company which requested anonymity. The three experiential trainees they had during 1997 were all registered with Mangosuthu Technikon prior to 1994. Although the feedback on them has not been excellent, they were found good enough to undergo training at the company. It was also confirmed that after three months on their rather rigorous training programme the experiential trainees had "got up to speed". In 1997, however, when students (who were registered in 1994 and after) attended interviews by this company for six possible positions for 1998, only one was found to be suitable. This clearly shows a deterioration in the performance of these potential chemical technicians.

Before 1994 ex-Mangosuthu Technikon students had been through the practically orientated bridging course and some semesters of the formal course. Students entering experiential training after 1994 (students can enter into experiential training at any level of their formal course) have clearly not displayed the same level of competence as those before. The bridging course in 1994 (see earlier) was a general "Access" course with large groups of students attending lectures after hours and with contract lecturers and of course no practical work. The course did, however, revert to a bridging course inclusive of practical work in 1995 but after-hours contact periods with contract staff were maintained and the course has never become part of the technikon's formal programme as before. The foundation given to students before 1994 was obviously beneficial but the same cannot be said of the 1994 year. Post-1994 courses are showing definite benefits but they have yet to reach the same heights as the initial Pre-Technician Course. The statistics will be analysed in sections to come.

12. **What are the areas that student technicians are least skilled in?**

The following areas were stated by most companies: quality assurance and control, time management, instrumentation and industrial lab knowledge. The other areas in which student technicians were found to be least skilled are: unfamiliarity with ISO 9000 and EN 45 000 series for industrial laboratories, lack of safety knowledge, statistics, computer literacy, specific knowledge of certain industrial technology (eg paint and/or petroleum technology), lack of integrated theory and practice, titration skills, trouble shooting, calibration techniques, report writing and intercultural communication.

13. What areas of course studies do you think should be emphasised?

The most common areas industry demanded from the course studies were: a greater emphasis on instrumentation techniques and applications (this appeared five times in the responses), relating theoretical knowledge to practical application (which appeared three times) and more emphasis on understanding of techniques used in wet chemistry. Also common were greater computer-based skills, report-writing skills and greater communication. Other areas included: trouble shooting, quality assurance, statistical techniques, accuracy and precision and safety. Two companies would like to see a focus in the course on specialised industrial knowledge (eg petroleum and paint technology) but accepted the fact that that would be difficult, given the general nature of a chemical technician's course. The importance of practical work was stressed by all the companies approached.

6.2.1 THE CASE FOR COMMUNICATION SKILLS

"The key to being an industrial chemist is to be a good communicator" (Journal of Chemistry and Industry, October of 1997:752) but, unfortunately, interpersonal skills (such as communication and teamwork) are rarely emphasised in technikon courses. Bridging courses, however, take the view that, since this is a particularly weak area for educationally disadvantaged students, it is very important to attempt to redress the lack of communication skills such students have.

6.2.2 COMMUNICATION SKILLS (a national perspective)

Most aspirant technikon students have matriculated with a pass in English Second Language. The majority of students attending historically black institutions face the unenviable prospect of learning and communicating in English. The second language has been taught to these students in a schooling system beset not only with inequities as noted previously but also incapable of effective delivery of education in a language other than mother tongue. Students who manage against great odds to come through the system and access tertiary education are accustomed to transmission mode teaching and reliance on poor learning strategies like memorisation (after Goodier, 1995). Thus, it is clear that for aspirant chemical technicians who are expected to cope with Mathematics and Science through a second language the problems are immense. It is also common cause that the tertiary system which the majority of South Africa's socioeconomically disadvantaged students wish to enter is one which caters predominantly for first language speakers of English as well as students suitably prepared for tertiary studies. A bridging course obviously needs to address those issues.

> With the changing student demography [in South African tertiary institution classes] many lecturers are finding that methods and approaches they have used successfully for years are no longer achieving the desired results. While traditionally successful students at the university have somehow always acquired the skills and processes vital to academic achievement either through their previous schooling, home background or from the lectures and readings themselves, educationally disadvantaged students need these skills and processes to be taught in explicit ways and to be shown how they are applicable in specific subject contexts" (English Quarterly, Vol. 26, 1994:17).

Academic Development, Academic Support and Communication departments have been established in all tertiary institutions to redress the problems of language. These too have their problems but suffice it to say they are tackling an enormous task and some success is being achieved.

6.2.3 COMMUNICATION SKILLS (an international perspective)

Institutions elsewhere in the world have also acknowledged the demands of industry for better communication skills from technicians. One example is a course offered to final year students at the Imperial College of London, which includes CV writing, oral presentation skills, interview skills, leadership qualities and writing skills. "Employers in the Chemical Industry and other areas have stressed the importance they attach to these skills, as well as academic ability and training, in job applicants. These skills are considered essential to success in an industrial environment" (Professor Spiro, Imperial College, London, 1995: interviewed by the writer while on a visit to the institution).

Another dedicated course which focuses on transferable skills for chemistry students is at the University of Wales, Bangor. Professor Weitzman in an address to Educationists at the "Variety in Chemistry Teaching" seminar in 1996 confirmed the above when he spoke of a "global revolution" in communications technology and the subsequent demand this will make on the tertiary institutions. "Society wants more flexible learning opportunities, and it wants to combine learning about, say chemistry, with acquiring broader transferable and learning skills....." (Variety in Chemistry Teaching Proceedings, 1996:9).

According to Lovell (1992), one needs also to consider management skills as part of communication skills.

> Manufacturers, accountants, salesmen, teachers and researchers all need management skills if they are going to excel in their chosen career (in Education in Chemistry, March 1992:60).

Lovell lists decision-taking, time management, prioritising and, of course, communicating with people as such skills.

According to Lovell it is the responsibility of "every academic department to [teach such skills]" (in Education in Chemistry, March 1992:60). This issue has been hotly debated as academics feel that courses for chemical technicians are sufficiently demanding and that there is insufficient time for such dedicated material. The approach to teaching such skills must be as an integrated feature and not simply an ad-hoc addition to the course. It appears that institutions would rather have companies offering their own in-house programmes which comply with their particular demands.

6.3 CONCLUSION

Possessing a knowledge-based certificate does not render a chemical technician suitably qualified. Jorgensen (1994) sums up the needs of Industry:

> Industry depends upon those who have problem solving skills, interpersonal skills, critical thinking skills, the abilities to reckon and master together with the capacity to function interdependently with others if necessary (Jorgensen, 1994).

6.4 REPORT ON INTERVIEWS WITH INDUSTRY REPRESENTATIVES

6.4.1 THE TASK SHEET AND INTERVIEW STRUCTURE

6.4.1.1 MEET WITH HEADS OF DEPARTMENTS

6.4.1.1.1 Meet with Heads of Departments:

Give a brief overview of the study and what is expected from the interview

6.4.1.1.2 Outline the questionnaire

Go over the questionnaire to clarify the responses

6.4.1.1.3 Establish the history of the experiential training programme

6.4.1.1.4 Establish which students are presently doing experiential training and the time period they have served

6.4.1.1.5 Where possible interview an experiential trainee

6.4.1.2 COLLECTION OF EXPERIENTIAL TRAINING INFORMATION

6.4.1.2.1 Determine the year the experiential trainee registered at the technikon

6.4.1.2.2 Determine the Course the experiential trainee registered for at the technikon

6.4.1.2.3 Take note of the particular bridging course the experiential trainee participated in at the technikon

6.4.1.2.4 Ascertain the status of the experiential trainee's study programme to date

6.4.1.2.5 If the experiential trainee has completed his study programme then learn from the trainee, how long it took him/her to complete the study period

6.4.1.2.6 Take note of the experiential trainee's secondary schooling history

6.4.1.2.6.1 Matriculation results

6.4.1.2.6.2 What practical science facilities were available and what practical science experience the trainee managed to obtain at secondary school

6.4.1.2.7 Record the experiential trainee's thoughts, on practical work in the bridging course, and the bridging course as a whole.

6.4.1.2.8 Determine how the practical work in the bridging course assisted the experiential service trainee with the formal course levels

6.4.1.2.9 Record the trainee's thoughts on practical work in the formal course

6.4.1.2.10 Ascertain which skills the trainee was confident with/what skills the trainee has been taught during experiential training programme/what the trainee would have liked included in the technikon course to prepare him/her for industry

6.4.2 INDUSTRY INTERVIEWS

6.4.2.1 UNILEVER

The Production Manager spoke briefly to the writer in October 1997. At that time Unilever had an experiential training programme but since 1991 it had become very limited. The company had only one trainee who was offered six months'experiential training (the student was from ML Sultan Technikon). The Production Manager's personal view was that students from technikons arriving for experiential training had been more confident and more able (practically) than University students but once in training the university students improved considerably and surpassed the technikon students. A possible explanation could be that the course taken by the technikon students was more practically orientated than that at university. The technikon students would have been more exposed to practical training whereas the university students would have received more theoretical tuition. The aptitude of the university students, however, seemed such that once in training they would be able to make up for lost time.

Unilever had a factory laboratory, linked to the process plant, in which there were twenty workers. Only three workers were graduates, from various institutes. Practical skills demanded of the experiential trainee by the laboratory were: an understanding of processes, flow charts and basic laboratory work. The Production Manager expressed his concern that experiential trainees appeared to have insufficient practical experience. His view was that tertiary institutions which have simulators available for tuition purposes should make greater use of them in order to prepare students more for real life. He also added that students should have more plant visits, which should be structured to make them relevant to their studies.

The Production Manager had been a student at Mangosuthu Technikon from 1988 to 1990 and had completed the Pre-Technician Course which was practically orientated. He stated that it was a most worthwhile course and had given him a good grounding. He concluded that since the schooling system was such that he had not been subjected to much practical work the practical work in the bridging course had been most beneficial.

The success of this student, who was a product of the practically orientated ("old") Pre-Tech course, suggests that students who have not had such a foundation to their formal course studies are not impressive in their performance in industry and cannot be compared with students who have had such an education.

6.4.2.2 HULS

The Human Resources Manager (HR) met with the writer in October 1997.

When asked about the experiential training policy of the company, the HR Manager stated that they received many applications for experiential training but took only one or two trainees, as the company was a small one. Experiential training had been offered for some years and one qualified employee had previously been an experiential trainee. Applicants did not have to meet any specific criteria but Huls was dependent on institutions for information about applicants. In that way the company acquired able students who could perform adequately.

The company had three integrated laboratories: Quality Control, Applications and Development. Eight employees were assigned to each laboratory. All employees except one had tertiary qualifications. These qualifications were from a university, except one, which was from a technikon. The HR Manager stated that when they offered experiential training the company worked closely with the educational institution and chose students according to institutions' recommendations. He also confirmed that the company offered a comprehensive in-house training programme which together with the training a student receives in the tertiary institution would meet requirements expected of a qualified technician. He also spoke positively about the "hands-on" experience of experiential trainees. The company was quite satisfied with the level of training the students had received when they arrived for experiential training. The HR Manager stressed that industry should have input into the bridging courses and the formal courses.

6.4.2.2.1 HULS : student interview

A Mangosuthu Technikon male student who was currently undergoing experiential training agreed to be interviewed by the writer.

When asked specifically about the practically orientated ("old") Pre-Technician Course the student was positive about it and claimed that students with whom he had obviously been in communication and who had been involved with the bridging courses after 1994 have been most dissatisfied.

This student had matric grades typical of the majority of Mangosuthu Technikon's aspirant students. He achieved an E (SG) for both Mathematics and Physical Science. At the secondary school he attended in Zululand he had had no practical experience. This student had registered in 1993, initially for the Pre-Technician Course. He was positive about the practical chemistry and physics work but felt that "*50% of the theory was similar to the S1 course*". He agreed that students from school backgrounds similar to his needed the Pre-Technician Course. After the Pre-Technician course (which he had successfully completed), he enrolled for the National Diploma in Chemical Engineering. He completed his theoretical study programme in December 1996 and was accepted for an experiential training period by Huls in March 1997 on a one-year contract. The student had an interesting observation on the practical work in the formal course; he felt that practical work was effective only when the lecturer involved was interested therein. He felt that all too often lecturers are not committed to practical work. He was enjoying his experiential training and felt fairly confident but, as is the case with any new job, he required some assistance. Huls training related his theoretical knowledge to the practical programme he was involved in, which he felt was most beneficial. He was most satisfied with his experiential training.

6.4.2.3 SAPREF

The writer met with the Recruitment Officer (RO), who had been in that position for under two years.

The two experiential trainees with SAPREF at that time (October 1997) were chemical engineers who had scholarships from SAPREF. They had worked with the company during their vacation periods and had at that stage completed their theory levels. They were doing a full 12 months' experiential training. Of the recent students taken onto their programme, the RO was of the opinion that the company's requirements far exceeded the abilities of the trainees. Technology from overseas and the continual demands to meet international standards had meant that demands on trainees had increased and frankly were not being met. Problems were even being encountered with university graduates whom SAPREF sponsor. In future the company was going to be able to offer this type of position only to scholars in the top echelon of the required training.

Interestingly, one of the experiential trainees was a student who had begun his course at Mangosuthu Technikon in 1994 and therefore had no practically orientated bridging course. The second student was from the 1995 batch of students. Neither student had been exposed to the original practically orientated bridging course.

The demands on practical skills for experiential trainees was, however, not that great since the trainee was under constant supervision and guidance.

The RO listed the areas in which trainees were not sufficiently skilled as, again, communications, computer skills and a lack of relevant industrial knowledge. The majority of trainees had little or no knowledge of SAPREF's functions. The RO claimed that students do not make informed decisions concerning their career choice.

Obviously, as written previously, the emphasis on computer skills, project work (in respect of related functions in industry) and increased liaison between industry and the technikons should be striven for by tertiary institutions.

6.4.3 CONCLUSION

Industry's input to this study was both interesting and informative. It is the writer's opinion that increased communication between industry and technikons would improve industry/technikon relations as well as providing important support for the experiential trainee. Industry could make valuable contribution to course content and practical tuition. If aspirant chemical technicians follow a study programme pertinent to local industry their chances of obtaining an experiential training contract and future advancement would be increased.

CHAPTER SEVEN

MANGOSUTHU TECHNIKON'S BRIDGING COURSES

7
7.1 INTRODUCTION

This chapter will assess the bridging courses offered at Mangosuthu Technikon in recent years. The writer has collected data from 1989 to 1997 about the bridging courses offered to students at Mangosuthu Technikon.

In 1993 the writer and a colleague analysed a sample of 100 students who had registered for the Pre-Technician Course at Mangosuthu Technikon between January 1989 and July 1990. The students' progress from the bridging course to the end of the formal course was traced. This data and the analysis were presented as a poster at the 32nd Convention of the Chemical Institute, in January 1994.

In 1994 the writer started collecting similar data concerning students who had registered for the general Access Course which was implemented in the technikon in 1994. The writer had been given set tasks by the Community Outreach Through International Linkages (COTIL) Project, a project sponsored by the Canadian Government, which linked the technikon with several Canadian Tertiary Institutions. One of the tasks involved a report on Mangosuthu Technikon's bridging course. The report compared the results of the previous Pre-Technician Course with the results of the Access Course introduced in 1994. The writer's findings were reported directly to COTIL and the Mangosuthu Technikon management. In the light of that report, the Access Course was abandoned and the bridging course was changed once again in 1995. The writer also presented these initial findings as a poster presentation at the 3rd European Conference on Research in Chemical Education (Poland) towards the end of 1995.

The Access course introduced in 1994 (only for that year) was different from the original bridging course at Mangosuthu Technikon. The original bridging course had been changed mostly for financial reasons. The bridging courses were funded by outside sponsors but it was known that by 1996 those funds would no longer be available. Mangosuthu Technikon was attempting to establish a strategy which would not be costly to the institution. There was also much speculation throughout the country as to the correct placing of a bridging course. One idea was to have such courses delivered by Technical Colleges, which would have been difficult, considering the lack of resources at such colleges, especially for practical work.

The Access Course was not practically orientated. The lectures were held outside normal technikon hours and staff involved were contract staff. The "general" nature of this bridging course meant that individual departments had very little input or influence on the course. The changed nature of the course stirred much debate. The majority of Chemistry and Chemical Engineering staff and students felt the course had been abandoned by the technikon. The interests and concerns in assisting educationally disadvantaged students who were not acceptable to the formal course were no longer apparent.

Prior to 1994, the Pre-Technician Course at Mangosuthu Technikon had always been a carefully planned course with input from all staff members. The course was not merely an 'add-on' course nor was the course just a 'quick fix' for a poor matriculation certificate. It combined matric work with preparation for the formal course. Previously learnt work was revised (in many cases corrected) and new work and concepts introduced on a firmer foundation. Students' confidence was built up. Practical work was integrated with theoretical knowledge. The emphasis on practical work was reinforced by all staff with practical tests included in the course and practical marks counting towards the student's overall assessment. The performances of these practically orientated bridging course students, once in the formal course, were always positively reported. Mangosuthu Technikon was not the only technikon to achieve this. It has been noted earlier by the writer that Port Elizabeth Technikon reported similar findings as did Border Technikon and Technikon Northern Gauteng.

The initial findings by the writer, submitted to COTIL and to the Mangosuthu Technikon management, showed a loss of potential tertiary students. The objective of the bridging course was always to retain potential students for the formal course and obviously (by offering a well-structured tuition programme) increase their chances of success at the formal level. If such objectives were not being met then the course had to be amended.

As stated above, the course reverted to the Pre-Technician Course specific to each department involved in that type of work. Departments were once again in control of their own potential formal students, practical work was reintroduced and class sizes reduced. Some of the negative features of the Access Course were still maintained, however; tuition and contact hours were outside the normal campus contact hours and contract staff were still involved with the course.

The following sections of this chapter will attempt to compare and assess the success of the various bridging courses that have been offered by Mangosuthu Technikon. The writer will attempt this in the following way:

(7.2) Students' bridging course results will be compared with their matriculation results.

(7.3) The number of successful students in the various bridging courses will be analysed.

(7.4) The performances of bridging course students, in the major subjects of Chemistry, Mathematics and Physics (at the bridging course level) will be investigated.

(7.5) The performances of successful bridging course students in the major subject of Chemistry I (first level of the formal course) will be investigated.

(7.6) The successful Pre-Technician Course students from the 1989/1990 sample will be followed through the formal course and compared with the performances, in the formal course, of successful Access Course (1994) students.

(7.7) Conclusions will be drawn.

7.2 THE SUCCESS OR NOT OF THE BRIDGING COURSE IN RESPECT OF IMPROVEMENT OF MATRICULATION RESULTS:

7.2.1 INTRODUCTION

According to Peter Hunter, "the need for bridging or academic support arises when a student's school experience is out of phase with the expectations of tertiary teaching" (Hunter, 1990:24). On examination of their Physical Science and Mathematics matriculation grades it is evident that there is a need for such support for these students and it remains to be seen whether the bridging courses have been able to address the problem adequately.

7.2.2 MATRICULATION RESULTS vs PRE-TECHNICIAN COURSE (1989 - 1990)

Information collected and presented in 1994 at the 32nd Convention of the South African Chemical Institute depicted matriculation results for a sample of 100 students who had enrolled for the Pre-Technician course over the period January 1989 to July 1990. The graphs (see Appendix 11, Lafferty and O'Brien, 1994) clearly indicate the poor matriculation grades obtained by these educationally disadvantaged students.

It must be noted that only Mathematics and Physical Science will be discussed. The criteria for entrance into the formal tertiary courses for aspirant chemical technicians requires a minimum E grade pass at the Higher Grade in both Mathematics and Physical Science and a pass in English. The subject Communication cannot be compared to matriculation English as the subjects are quite different,whereas the bridging course work for Mathematics and Physical Science is not simply a repeat of the matriculation work but also includes an introduction to work at the higher formal level.

7.2.2.1 Mathematics and Physical Science:

With reference to the graphs (see Appendix 11, Lafferty and O'Brien, 1994), the majority of matriculation grades obtained by the students in these subjects are D and E grades in HG or SG. As stated earlier, such grades would not allow direct access to the formal National Diploma courses. The bridging course was an attempt at improving on such grades.

The results achieved by the students at the end of the Pre-Technician Course show a definite improvement (see Appendix 12, Lafferty and O'Brien, 1994). The Mathematics grades obtained in the bridging course show a spread from A to F grades with the majority of grades being C and D grades,which is clearly an improvement. The Chemistry grades obtained in the bridging course are also spread from A to F grades with the majority of grades being B,C,D and Es. These grades depict a definite improvement in the students' results for the relevant subject. The criteria for admission to the formal course remains the same for a matriculation student and/or a bridging course student. With improved results, however, the students could gain access to the formal course.

The relevance of the Mangosuthu Technikon Bridging Course is confirmed by these results and by the fact that 75% of these students progressed to the formal course S1 (after Lafferty and O'Brien, 1994).

7.2.3 MATRICULATION RESULTS vs ACCESS COURSE (1994) and PRE-TECHNICIAN COURSE (1995 and 1996)

In 1994, 1995 and 1996 the writer collected matriculation grades for the bridging course students registered in the School of Chemistry and Chemical Engineering and these are compared below with corresponding subjects results obtained in the bridging courses.

Matriculation Results vs Access Course (1994)

7.2.3.1 Physical Science

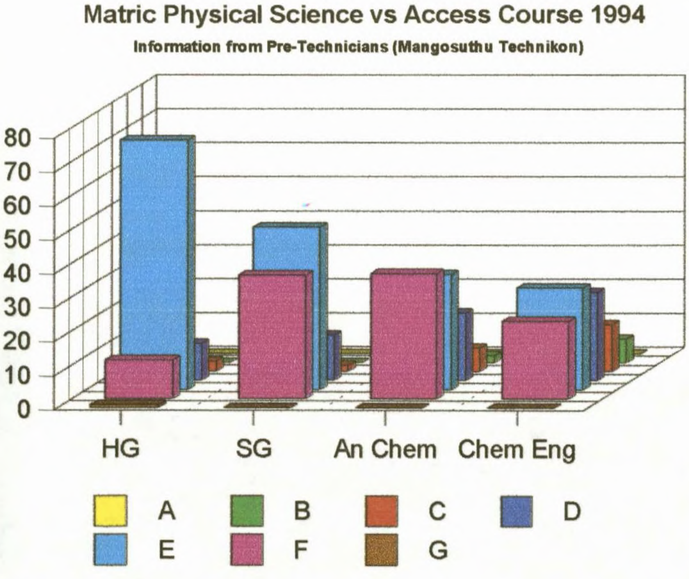
Table 5 compares Physical Science grades to the Access Course Chemistry results for 1994 (both semesters). Students register as Analytical Chemistry students or Chemical Engineering students, depending on their choices of careers, hence results are shown for the two separate disciplines (An Chem and Chem Eng).

(NOTE: All results are given as % of the total for that column).

TABLE 5 MATRICULATION PHYSICAL SCIENCE RESULTS vs RESULTS OF STUDENTS REGISTERED FOR ACCESS COURSE 1994

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	0	0
B	0	0	2	7
C	3	2	7	14
D	11	13.5	20	26
E	73.5	48	34	30
F	11.5	36.5	37	23
G	1	0	0	0
TOTAL	100	100	100	100

Figure 14



The Access Course shows a slight increase in the B, C and D grades obtained by students for the science subject at this level when compared to the grades obtained for Physical Science in matric. There is however an increase in the number of F grades at the Access Course level for this subject. The students did not improve significantly on their matriculation results and this would account for the low number of students who were able to access formal tuition.

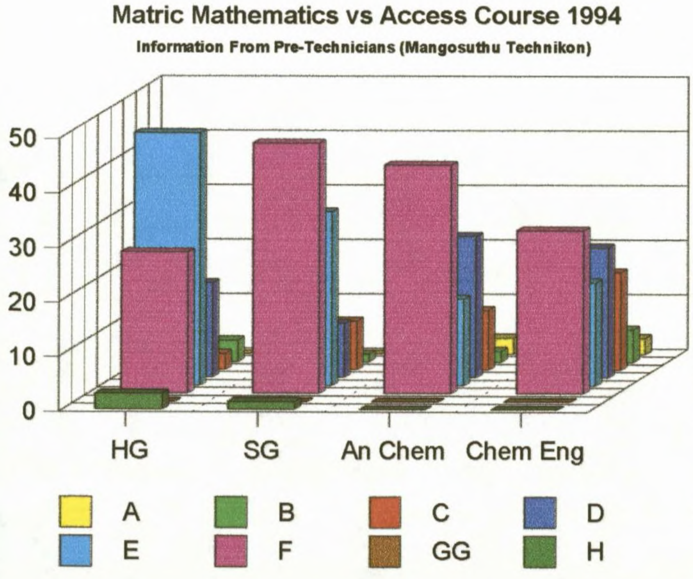
Matriculation Results vs Access Course (1994)
7.2.3.2 Mathematics

(**NOTE**: All results are given as % of the total for that column).

TABLE 6 MATRICULATION MATHEMATICS RESULTS vs RESULTS OF STUDENTS REGISTERED FOR ACCESS COURSE 1994

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	3	3
B	4	1.5	2	6
C	3	9	11	18
D	17.5	10	26	24
E	46.5	32	16	19
F	26	46	42	30
GG	0	0	0	0
H	3	1.5	0	0
TOTAL	100	100	100	100

Figure 15



The Access Course results for Mathematics are slightly better than the matriculation results for Mathematics (an increase in D and C grades).

There is an overall improvement, albeit slight, in grades for Physical Science and Mathematics obtained in the Access Course (bridging course) when compared to the grades obtained in the matriculation examinations.

7.2.4 MATRICULATION RESULTS vs PRE-TECHNICIAN COURSE (1995)

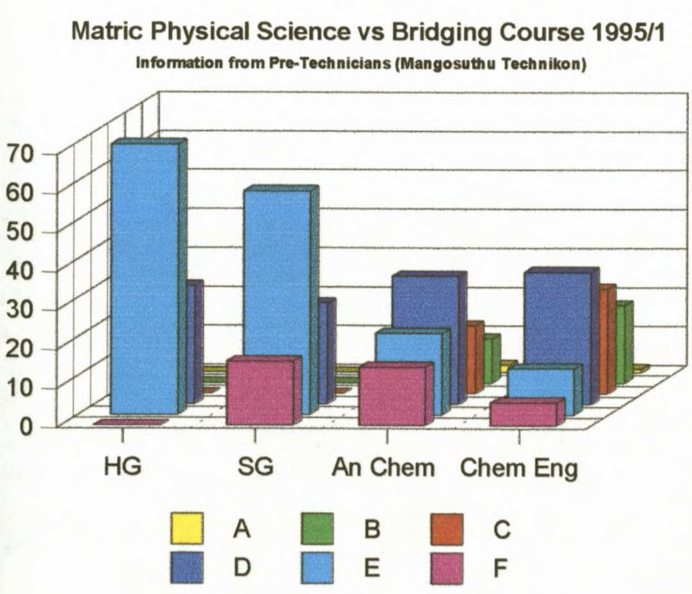
7.2.4.1 Physical Science (semester 1).

(**NOTE**: All results are given as % of the total for that column).

TABLE 7 MATRICULATION PHYSICAL SCIENCE RESULTS vs BRIDGING COURSE RESULTS OF STUDENTS REGISTERED FOR PRE-TECHNICIAN COURSE 1995/1

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	2	1
B	0	0	11.5	20
C	0	0	17.5	27
D	30.5	26	33	34
E	69.5	57.5	21	12
F	0	16.5	15	6
TOTAL	100	100	100	100

Figure 16



A definite improvement is noticed in student achievements in the science subject done during the Pre-Technician Course (bridging course).

The number of B and C grades has increased substantially (and to a lesser degree the D grades) in the bridging course science subject compared to the high number of D and E grades obtained in matriculation Physical Science.

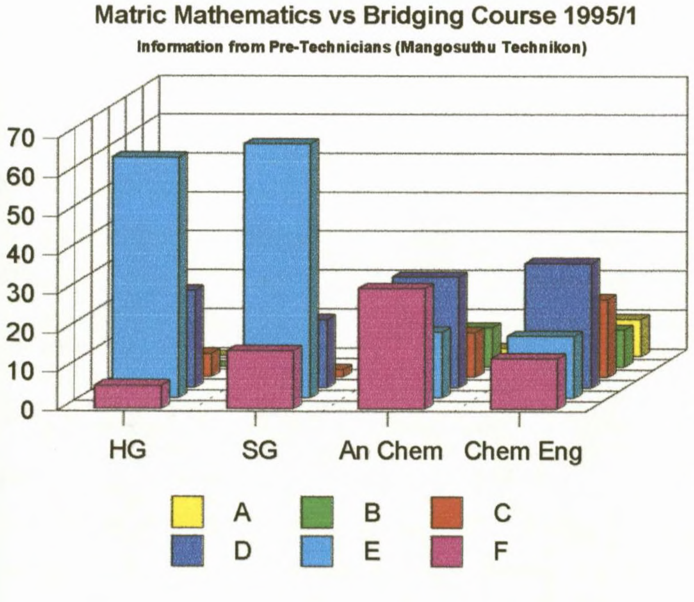
Matriculation Results vs Pre-Technician course (1995)
7.2.4.2 Mathematics (semester 1).

(**NOTE**: All results are given as % of the total for that column).

TABLE 8 MATRICULATION MATHEMATICS RESULTS vs BRIDGING COURSE RESULTS OF STUDENTS REGISTERED FOR PRE-TECHNICIAN COURSE 1995/1

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	2	9.5
B	0	0	10	9.5
C	6	2	11.5	20
D	25	17.5	28.5	32
E	62	65.5	17	16
F	6	15	31	13
TOTAL	100	100	100	100

Figure 17



The increase in grades A to D for Mathematics in the Pre-Technician Course (bridging course) results is evident. Students could not access the tertiary course with low grades so these improved results have enabled students to access the formal course.

7.2.5 MATRICULATION RESULTS vs PRE-TECHNICIAN COURSE (1995)

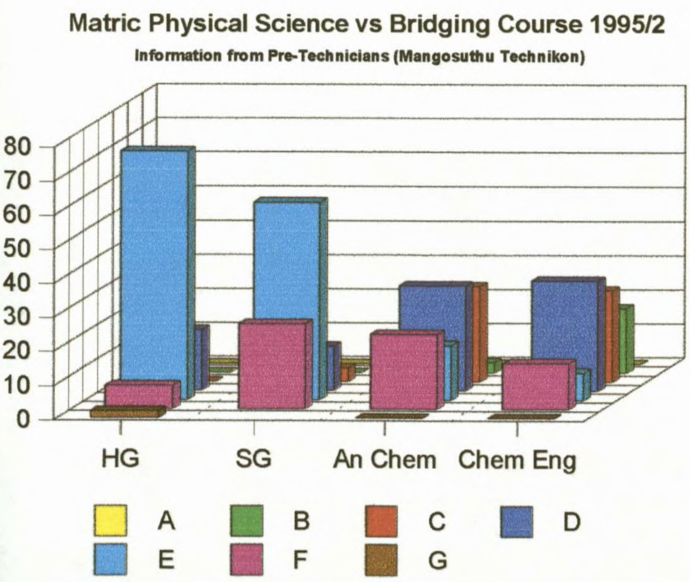
7.2.5.1 Physical Science (semester 2).

(**NOTE**: All results are given as % of the total for that column).

TABLE 9 MATRICULATION PHYSICAL SCIENCE RESULTS vs BRIDGING COURSE RESULTS OF STUDENTS REGISTERED FOR PRE-TECHNICIAN COURSE 1995/2

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	0	0
B	0	0	3	19
C	0	4	28	27
D	18	13	31	32.5
E	73	58	16	8
F	7	25	22	13.5
G	2	0	0	0
TOTAL	100	100	100	100

Figure 18



There appears to be a remarkable improvement in the grades of the bridging course science subject (particularly the B,C and D grades) as opposed to the rather dismal Physical Science grades obtained by the students in matric.

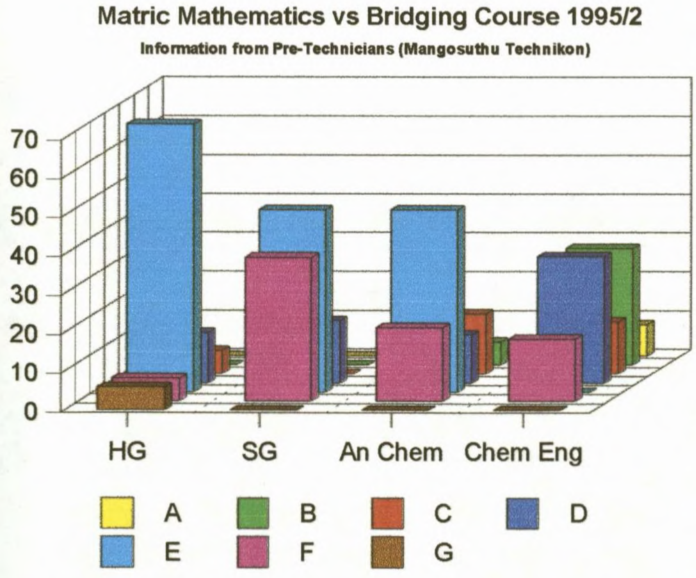
Matriculation Results vs Pre-Technician course (1995)
7.2.5.2 Mathematics (semester 2).

(**NOTE**: All results are given as % of the total for that column).

TABLE 10 MATRICULATION MATHEMATICS RESULTS vs BRIDGING COURSE RESULTS OF STUDENTS REGISTERED FOR PRE-TECHNICIAN COURSE 1995/2

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	0	8
B	0	0	6	30
C	6	0	15.5	13.5
D	13	16	12.5	32.5
E	69	47	47	0
F	6	37	19	16
G	6	0	0	0
TOTAL	100	100	100	100

Figure 19



The E grades are the majority grades in the matric Mathematic results as well as the Pre-Technician Course (bridging course) for the Analytical Chemistry students. Not much change is evident. However, the Chemical Engineering students' bridging course results for Mathematics depict an overall improvement on the matric Mathematics grades. There is also a substantial increase in the numbers of B and C grades obtained by both groups of students in the Pre-Technician Course. No such grades were obtained by the students in the Matriculation examination.

7.2.6 MATRICULATION RESULTS vs PRE-TECHNICIAN COURSE (1996)

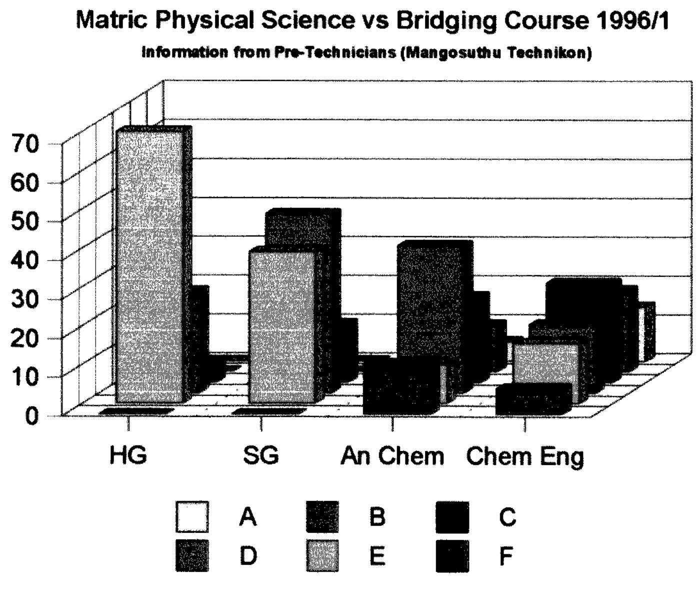
7.2.6.1 Physical Science (semester 1)

(**NOTE**: All results are given as % of the total for that column).

TABLE 11 MATRICULATION PHYSICAL SCIENCE RESULTS vs BRIDGING COURSE RESULTS OF STUDENTS REGISTERED FOR PRE-TECHNICIAN COURSE 1996/1

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	5	14
B	0	0	12	21
C	4	15	22	25.5
D	26	46	38	17.5
E	70	39	10	15.5
F	0	0	13	6.5
TOTAL	100	100	100	100

Figure 20



A feature with this set of results (not visible from the graph detail) is the large percentage of HG symbols compared to SG symbols in the matriculation Physical Science results i.e. the SG results constitute only 20.5% of the total grades. The question worth pursuing would be: Is this an improvement in secondary pupils performances in Physical Science or is the technikon attracting students with better grades? Another noticeable feature is the overall improvement by the students in the Pre-Technician Course (bridging course).

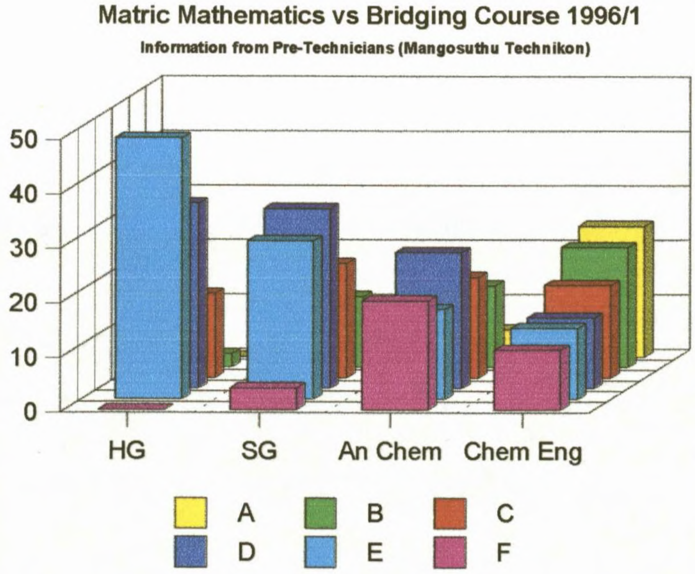
Matriculation Results vs Pre-Technician course (1996)
7.2.6.2 Mathematics (semester 1).

(**NOTE**: All results are given as % of the total for that column).

TABLE 12 MATRICULATION MATHEMATICS RESULTS vs BRIDGING COURSE RESULTS OF STUDENTS REGISTERED FOR PRE-TECHNICIAN COURSE 1996/1

GRADE	Matric HG	Matric SG	Pre-Tech An Chem	Pre-Tech Chem Eng
A	0	0	5	24
B	2.5	13	15	22
C	15.5	21	18.5	17
D	34	33	25	13
E	48	29	16.5	13
F	0	4	20	11
TOTAL	100	100	100	100

Figure 21



A definite improvement is clearly seen in the performance of students in the Pre-Technician course Mathematics.

An increase in the number of higher grades obtained by students in the Pre-Technician course compared to the number obtained by the students during their matric is again evident.

7.2.7 CONCLUSION

The information derived from the collected data clearly depicts success for the bridging courses in terms of their improving on the matriculation grades for the subjects of Physical Science and Mathematics. Passing those two matriculation subjects would meet the criteria for acceptance into the formal tertiary course but, clearly, students have not been able to meet the criteria with their dismal matriculation grades. The Pre-Technician course has allowed them an opportunity to improve their grades. The Chemistry and Mathematics courses although not identical to the matriculation subjects, are based on matriculation work and include an introduction to the formal course work.

The Access Course results, by comparison with the original Pre-Technician course results and the proceding Pre-Technician course results, did not show a significant improvement. The Access Course (general bridging course) thus offered the students little by way of improvement on the secondary schooling system from which they had come. The classes were outside the normal tuition periods for the formal courses, classes were large in size, the practical work, which they had been looking forward to taking part in, was nonexistent and only contract staff were available. It is unlikely that such a course would motivate a student faced by the challenges of tertiary education.

The writer holds these opinions because of her involvement with local high school pupils, teachers and local NGOs. Communication between the writer and these various role players gave the writer an overview of the conditions within the schools and in particular the inadequacies concerning the teaching of Physical Science. Through planning and organisation of 'fun' workshops carried out by the writer and her staff, pupils were able to visit the campus and take part in practical workshops. Feedback from teachers and technikon staff was positive and as a result more workshops and assistance have been given to these pupils. It was, therefore, a disappointment for students enrolling for the Access Course in 1994 to find out that the course held few surprises and in fact was mainly 'chalk and talk' — a repetition of their secondary school experience.

However, the results achieved by students in the Pre-Technician Courses (inclusive of some practical work) have shown a distinct improvement on the matriculation grades. These bridging courses would appear to be instrumental in ensuring that students are able to access tertiary education successfully.

7.3 SUCCESS OF THE BRIDGING COURSE IN TERMS OF STUDENTS PROGRESSING INTO THE FORMAL/MAINSTREAM DIPLOMA COURSE

7.3.1 INTRODUCTION

To assess the success of a bridging course let us revisit the definition of a bridging course. Peter Hunter describes such a course as:

> a structured teaching arrangement which takes the form of a year of study and/or practical training which is completed before entry to a tertiary curriculum. This tuition may take place at the tertiary institution, or an intermediate institution established specifically to provide this bridging function. ...In the simplest terms, the need for bridging or academic support arises when a student's school experience is out of phase with the expectations of tertiary teaching (Hunter, 1990:24).

Consequently, for a bridging course to be successful, the course should be completed by the student in such a way that the student is *in phase* with the demands of tertiary learning. A student's successful completion of the course, having passed the relevant subjects, should mean that the tuition has redressed the deprivations of his secondary education and that he has a greater chance of succeeding at the tertiary level.

This section of the chapter will analyse the success of the bridging courses in terms of students' progress from the bridging course into the formal or mainstream courses (see Table 13). As stated earlier, disadvantaged students have had little opportunity to access tertiary study, since they could not meet the criteria set down by technikons for entrance into formal courses, but a bridging course should allow them a second opportunity to access a particular course. The issue which will be considered here is whether or not a bridging course does so - in this case, whether or not the Mangosuthu Technikon Pre-Technician Course is successful.

TABLE 13 PASS RATE OF STUDENTS AT THE BRIDGING COURSE LEVEL

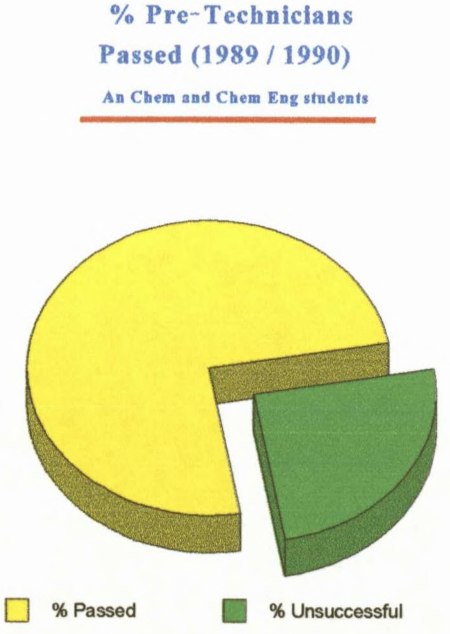
YEAR	COURSE TYPE	% PASS/SUCCESSFUL (at the bridging course level - acceptable for the formal course)	% UNSUCCESSFUL (at the bridging course level - not acceptable for the formal course)
1989/1990	Pre-Tech (old)	75	25
1994	Access	33	77
1995	Pre-Tech (new)	38	62
1996	Pre-Tech (new)	44	56
1997	Pre-Tech (new)	46	58

7.3.2 BRIDGING COURSE (1989 - 1990)

As has been noted earlier (see Chapter 3) the bridging course's results of a sample of 100 students who registered for the Mangosuthu Technikon Pre-Technician Course over the period January 1989 to July 1990 were analysed and presented in a poster presentation at the 32nd Convention of the South African Chemical Institute in 1994 (Lafferty and O'Brien, 1994). The success of those students at the Pre-Technician level as well as their continued performance throughout the course was analysed.

75% of the sample of 100 progressed to the formal course. The following pie graph depicts this result and suggests a success story for the Pre-Technician Course at Mangosuthu Technikon.

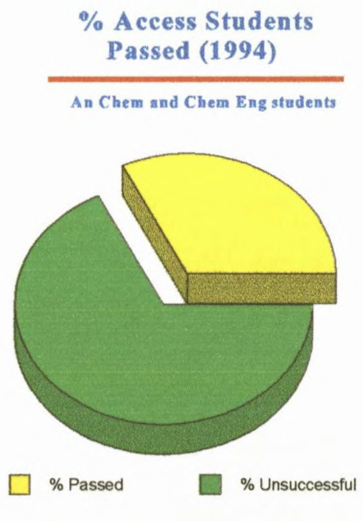
Figure 22



7.3.3 ACCESS COURSE (1994)

The total number of students registered for the Access Course (a general course) was 290. The writer made use of all 290 students for the data collection. There were 149 Analytical Chemistry students and 141 Chemical Engineering students. 30% of the Analytical Chemistry students passed the course and were promoted to the first formal level. 35% of the Chemical Engineering students were successful at the bridging course level and were able to access tertiary education. The following pie-graph depicts this result clearly.

Figure 23

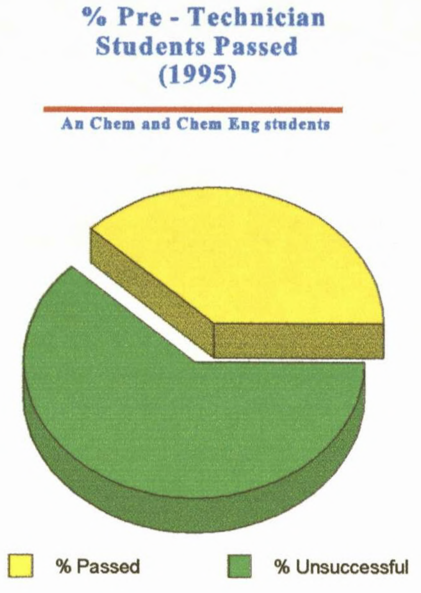


Only a small number of students from the Access Course were successful and able to access tertiary education. The loss in revenue and resources to the students, their families and the institution were enormous. Regulations did not permit students to register for a second attempt so the consequences of failure were harsh.

The dissatisfaction of students and staff, aided by the writer's earlier study of the results, by the writer, effected yet another change to the course: the Pre-Technician Course with practical work was reintroduced, but not in its entirety. The course was implemented outside formal course hours and the staff were not permanent staff but contracted in. The results of the following years will now be analysed.

7.3.4 PRE-TECHNICIAN COURSE (1995)

Figure 24

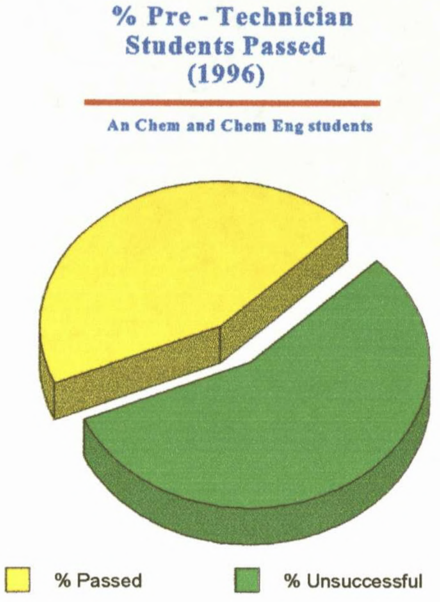


There appears to be a slight improvement in the pass rate of students into the first level of the formal course. 38% of the total number of students were successful. The pass rate of 75% achieved by the 'old' Pre-Technician Course however still appeared to be difficult to match.

7.3.5 PRE-TECHNICIAN COURSE (1996)

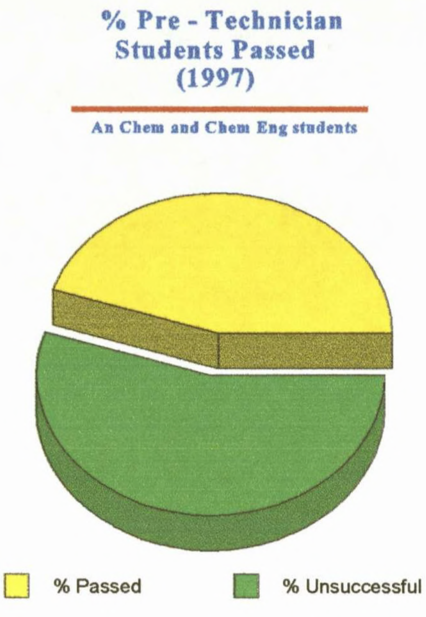
Figure 25

It is encouraging to see from these results that the pass rate of bridging course students is improving. 44% of the total number of students were successful and could access tertiary education.



7.3.6 PRE-TECHNICIAN COURSE (1997)

Figure 26



The 46% pass rate is a very slight improvement on the previous year and it is to be hoped that it will increase each successive year; improvement, however slight, is encouraging. The end result is that more students are able to access tertiary education which is the objective of the bridging course.

7.3.7 CONCLUSION

In this section the writer has compared the various bridging courses by analysing their eventual pass rates. The Pre-Technician Course (1989/1990) students performed well and the majority of them were able to access tertiary education. The Access Course (1994) students, however, performed dismally. The pass rate of 30% and 35% was disappointing and costly to all role players. The subsequent years have seen an improvement in the pass rates. The 75% pass rate however appears as a distant goal. The question which has been raised is, "Why can't the Pre-Technician Course revert to a 75% pass rate, as per the 1989 - 1990 intake?" It is the writer's opinion that amendments to the existing course must be made to bring about an increase in the pass rate. This would mean a complete reversion to the Pre-Technician Course as it was administered prior to 1994. The bridging course would need to be acknowledged as one of the department's courses, permanent staff would need to be involved with the course, the students would need to be accepted by and registered in the specific departments, and the necessary commitment to the course would need to be made by all parties concerned. In that way, the writer believes, the goal can not only be achieved, but improved upon.

7.4 SUCCESS OF THE BRIDGING COURSE IN RESPECT OF STUDENT PERFORMANCES IN THE MAJOR SUBJECTS (CHEMISTRY, MATHEMATICS AND PHYSICS) AT THE BRIDGING COURSE LEVEL.

7.4.1 INTRODUCTION

This section will be an investigation into the success of the bridging course in terms of student performances in the major subjects Chemistry, Chemistry Practical, Physics and Mathematics. Results of all subjects passed will also be shown. The writer has collected data on the bridging course results from 1992 to 1997 inclusive.

The years 1992 and 1993 refer to the 'old' Pre-Technician Course (the course was specific to the department, administered during normal campus times, practically orientated, and involved formal course staff). In 1994 the course changed to the general Access Course (the course was administered outside normal contact hours, no practicals were included, and the course involved contract staff). In 1995 the course reverted to a specific course for Pre-Technicians once again (practical work was included but the course was still administered outside normal contact hours and included contract staff). This Pre-Technician Course is extant at the time of writing.

7.4.1.1 Pre-Technician students performances from 1992 - 1997

The writer has collected data from 1992 so as to give a clear indication of the bridging course results prior to 1994 against which the Access Course results of 1994 can readily be compared. The data from the years following the Access Course have also been collected for similar comparisons (see Table 14).

An analysis of Pre-Technician results from 1992 to 1997 is shown in Table 14 below. Of interest is the fact that the highest number of students enrolled during a semester was in the general Access Course which was the course introduced in 1994 for that year only.

TABLE 14 MAJOR SUBJECTS STATISTICS 1992 - 1997

(Note: i: Figures in parentheses are the number of students passed, expressed as a % of the total number of students enrolled.

ii: 1996 figures are given over two semesters as the computer records combined the two disciplines' results in the second semester 1996)

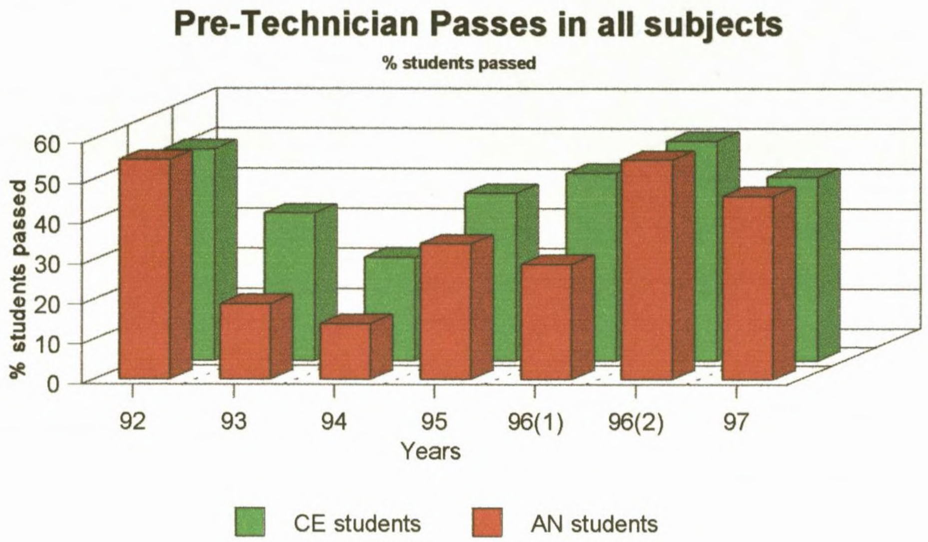
YEAR	TYPE	CHEMISTRY Enrolled/Pass	CHEMISTRY PRACTICAL Enrolled/Pass	MATHS Enrolled/Pass	PHYSICS Enrolled/Pass	All subjects passed
1992	AC	34/31 (91%)	35/31 (88%)	40/30 (75%)	40/27 (68%)	55%
1992	CE	62/57 (92%)	62/53 (85%)	62/51 (82%)	62/48 (77%)	53%
1993	AC	48/44 (92%)	47/37 (79%)	62/38 (61%)	59/28 (47%)	19%
1993	CE	92/83 (90%)	91/78 (86%)	99/78 (79%)	103/58 (56%)	37%
1994	AC	151/39 (26%)	no pracs	149/58(39%)	151/39 (26%)	14%
1994	CE	141/63 (45%)	no pracs	141/68(48%)	141/63 (45%)	26%
1995	AC	88/54 (61%)	88/66 (75%)	88/37(42%)	88/39 (44%)	34%
1995	CE	127/96 (76%)	127/89 (70%)	127/88(69%)	127/89 (70%)	42%
1996 SEM1	AC	24/20 (83%)	24/16 (67%)	24/22 (92%)	24/13 (54%)	29%
1996 SEM1	CE	92/71 (77%)	92/84 (91%)	92/69 (75%)	92/51 (55%)	47%
1996 SEM2	AC & CE	87/65 (75%)	87/69 (79%)	87/54 (62%)	87/52 (60%)	55%
1997	AC & CE	184/115 (62%)	184/165 (90%)	184/132(72%)	184/110(60%)	46%

1994 was disastrous for aspirant Analytical Chemistry and Chemical Engineering students who followed the general Access Course. The general Access Course (1994) shows a lower % overall pass-rate and a lower % pass-rate in Chemistry, compared with all the other years. Many students who could have been retained in 1994 for the formal course were lost to tertiary studies. This was a loss not only for the students and their families but also in resources for the institution (the % of students who successfully completed the course in 1994 was far less than ever before; only 30% of the analytical chemistry students were promoted to the formal course and 35% of the chemical engineering students were promoted to the formal course).

7.4.1.2 All subjects passed

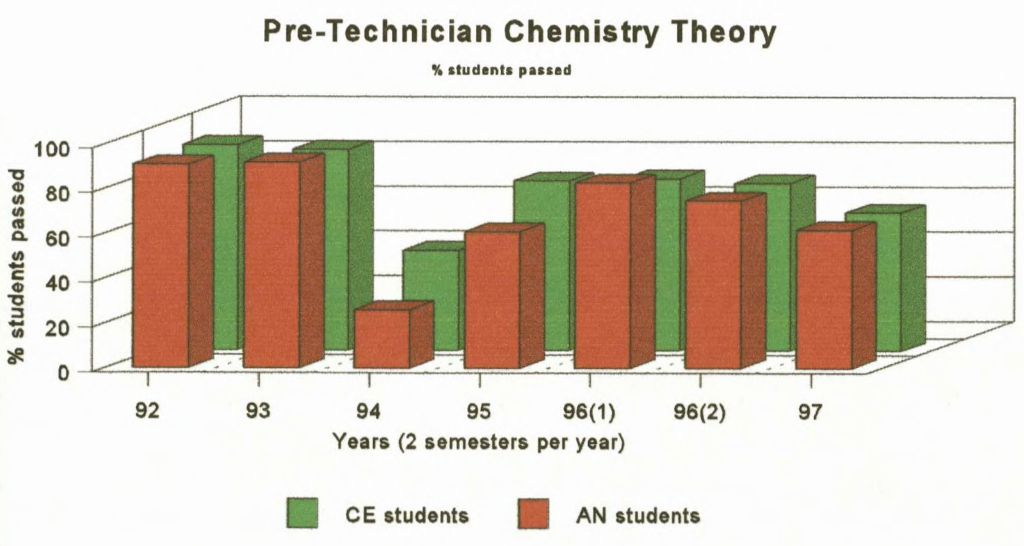
A similar poor trend in the % of students who passed all subjects was also observed (see Figure 27): the lowest number of students passing all subjects is observed in the year 1994.

Figure 27



7.4.1.3 Chemistry Results

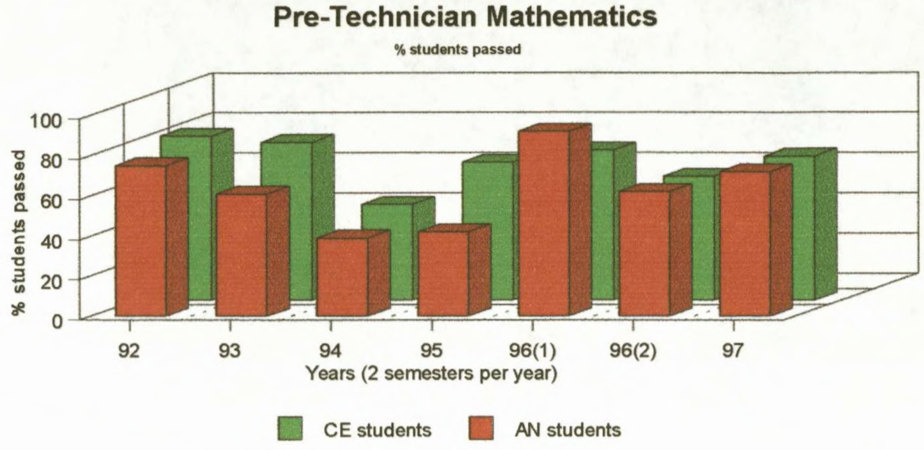
Figure 28



The graphical representation clearly shows the poor results obtained by students for Chemistry in 1994. There is an improvement in the succeeding years but the high pass-rate results of the preceding Pre-Technician Course have yet to be re-attained.

7.4.1.4 Mathematics Results

Figure 29

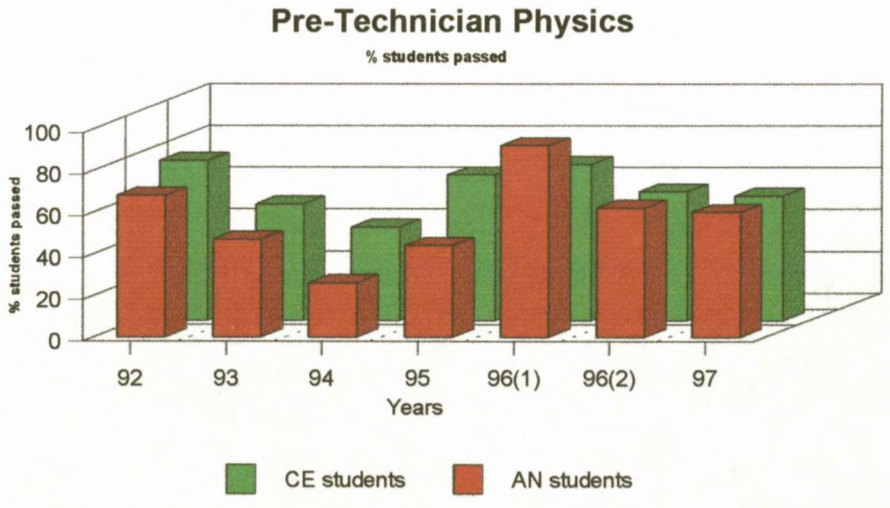


The Mathematics results depict a similar graphical trend to the Chemistry results.

The results achieved by students in the Access Course (1994) are much lower than the preceding years and also lower than the succeeding years.

7.4.1.5 Physics Results

Figure 30



The poor results of 1994 continue in this graphical depiction of the Physics results obtained by bridging course students.

Both disciplines show a poor performance in 1994 when compared to the preceding and succeeding years.

7.4.2 CONCLUSION

The number of students passing the Pre-Technician Courses (1992-1994 and 1995 -1997) is higher than the number of students who passed the Access Course in 1994. The number of students who passed all subjects has been shown (see Figure 27). The very low % of students who passed all subjects in 1994 is considerably lower than in other years. The results given above also clearly show that the % pass-rate in the main subjects of Chemistry, Physics and Mathematics dropped substantially in the year 1994 compared with those before and after the Access Course. As stated earlier before the results of a general course (Access Course) introduced in 1994 for disadvantaged students did the students a disservice. The loss in revenue to students, families and the institution was high.

7.5 SUCCESS OF THE BRIDGING COURSE IN RESPECT OF STUDENT PERFORMANCES IN THE MAJOR SUBJECT OF CHEMISTRY AT THE FIRST LEVEL OF THE FORMAL COURSE.

7.5.1 INTRODUCTION

This section focuses on the success of the bridging course in terms of students' performances in the major subject, Chemistry, in the first formal level of the National Diploma in Analytical Chemistry and National Diploma in Chemical Engineering. Chemistry occurs in the bridging course and the first formal level, S1. In the second formal level, S2, the chemistry courses become more specialised, i.e. Analytical Chemistry, Physical Chemistry, Organic Chemistry and Inorganic Chemistry. The Analytical Chemistry Diploma students continue in this vein through to S4 whereas the Chemical Engineering Diploma students face more engineering-focused subjects from S3 level onwards. Practical work in the chemistry laboratory is a priority with Analytical Chemistry students throughout the course whereas the Chemical Engineering Diploma students have limited chemistry laboratory practical work from S2 level onwards.

7.5.1.1 Ex Pre-Technician and Access students performances at the S1 formal level (Chemistry I Theory)

In order to determine the effect the Access Course had on the performance of students in S1 level, one must concentrate on the results of S1 students in the 1994 second semester and students' results from the 1995 first semester.

Most data collected was textual as the Mangosuthu Technikon computer system includes re-writes, which could not be used, and as a result does not trace the progress of individual students over the years. The computer merely reports numbers enrolled, numbers passed and grades obtained; not individual results. However, the writer traced individual students through class lists where available. Some student information has not been recorded at all onto the computer. One reason is that students who have outstanding fees do not have their information available on the system.

The writer has tabulated all the results of the number of students enrolled annually and the number of students who passed Chemistry I Theory, for both Analytical Chemistry and Chemical Engineering from 1992 to 1997 inclusive (see Table 15).

TABLE 15 FORMAL COURSE FIRST LEVEL (T1 OR S1) CHEMISTRY THEORY RESULTS 1992 - 1997

S1 Chemistry (Analytical Chemistry)		S1 Chemistry (Chemical Engineering)	
1992 sem 1 (T1)	No chem - chem written at previous Pre-Tech level	**1992 sem1 (T1)**	No chem - chem written at previous Pre-Tech level
1992 sem 2 (T1)	19 enrolled 15 passed (79% passed) 54% ave mark	**1992 sem 2 (T1)**	35 enrolled 32 passed (91%passed) 60% ave mark
1993 sem 1	24 enrolled 16 passed (67% passed) 58% ave mark	**1993 sem 1**	26 enrolled 18 passed (69% passed) 56% ave mark
1993 sem 2	25 enrolled 24 passed (96% passed) 64% ave mark	**1993 sem 2**	49 enrolled 42 passed (86% passed) 62% ave mark
1994 sem 1	29 enrolled 12 passed (41% passed) 48% ave mark	**1994 sem 1**	54 enrolled 36 passed (67% passed) 55% ave mark
1994 sem 2	43 enrolled 24 passed (61% passed) 48% ave mark	**1994 sem 2**	65 enrolled 41 passed (63% passed) 51% ave mark
1995 sem 1	35 enrolled 28 passed (80% passed) 54% ave mark	**1995 sem 1**	63 enrolled 50 passed (79% passed) 57% ave mark
1995 sem 2	26 enrolled 23 passed (88% passed) 61% ave mark	**1995 sem 2**	66 enrolled 58 passed (88% passed) 61% ave mark
1996 sem 1	30 enrolled 24 passed (80% passed) 57% ave mark	**1996 sem 1**	75 enrolled 51 passed (68% passed) 59% ave mark

1996 sem 2	31 enrolled 28 passed (90% passed) 52% ave mark	**1996 sem 2**	70 enrolled 62 passed (89% passed) 62% ave mark
1997 sem 1	15 enrolled 12 passed (80% passed) 54% ave mark	**1997 sem 1**	50 enrolled 42 passed (84% passed) 54% ave mark
1997 sem 2	15 enrolled 14 passed (93% passed) 58% ave mark	**1997 sem 2**	46 enrolled 42 passed (91% passed) 61% ave mark

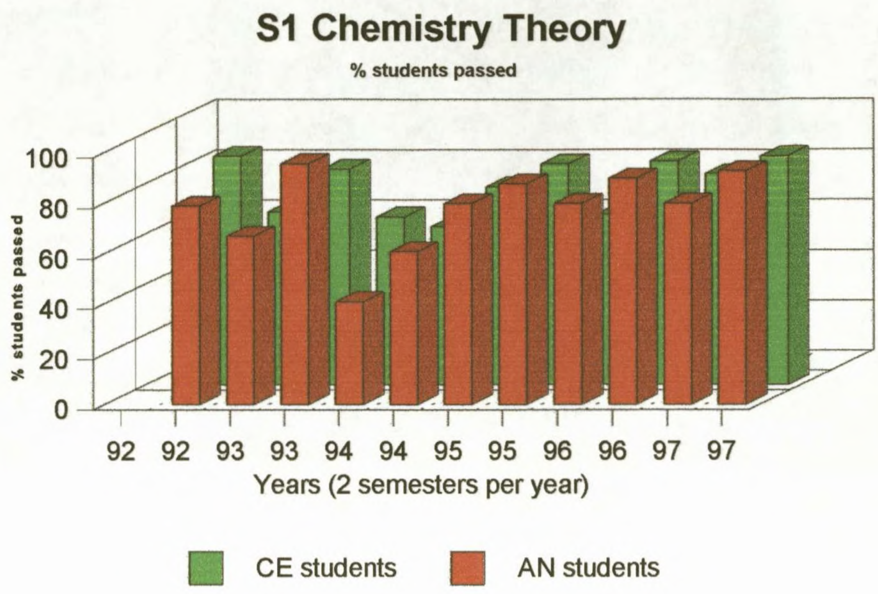
7.5.1.1.1 Discussion

In the above table the first point of interest is that Chemistry was not a subject for T1 students in 1992 as it was a credit bearing subject at the Pre-Technician level. (The T courses changed to S courses in 1993). Secondly, the rather dismal results for the first semester in 1994 must be explained. In 1994 semester 1, the pass-rate was 41% which was poor by comparison with the previous semesters, which averaged pass-rates of between 67% and 96%.

In the first semester of 1994 many of the students who registered for the S1 course were not the normal successful *at first attempt* students from the Pre-Technician Course. They were not students who had been successful in an initial attempt at the 1993 bridging course but (through administrative errors and possibly because normal strict controls lapsed when the change from the old Pre-Technician Course to the general Access Course was imminent) had been allowed back into the bridging course and given a second chance. This was never intended to be an option. Unfortunately such events do sometimes occur and it was clear from their performance in the S1 level that they would always be *high risk* students and would struggle to complete the formal course. Hence the rather dismal results of the S1 course in the first semester of 1994. (After that semester a much stricter control was implemented once again for the bridging course students and no student may attempt a bridging course for a second time).

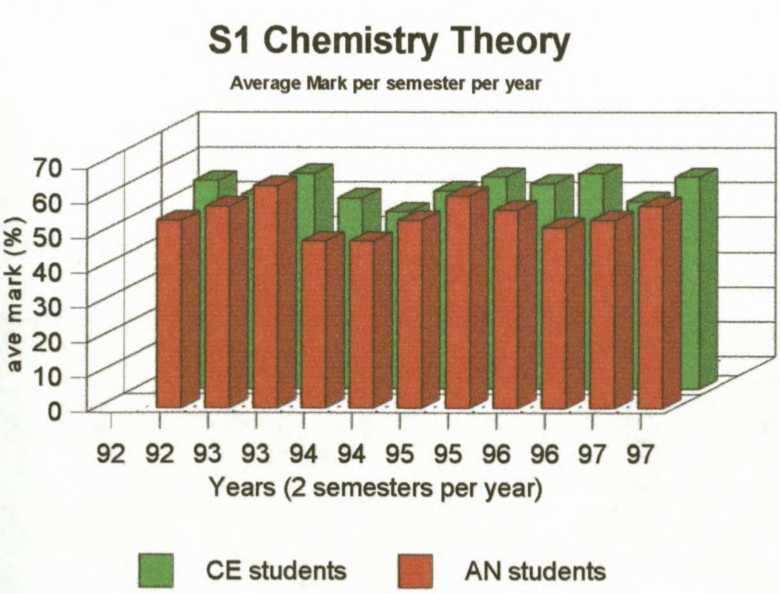
The semesters of particular interest to the writer are the second semester of 1994 (the first batch of successful Access Course students) and the first semester of 1995 (the second batch of successful Access Course students). The overall pass-rates were 61% and 63% (first and second semester analytical chemistry students) and 80% and 79% (first and second semester chemical engineering students). The first semester pass-rate is lower than the norm and when compared to semesters after 1994/1995 is still lower than expected. The actual % marks obtained by the students who were ex-Access Course are 48% and 51% (analytical chemistry students) and 54% and 57% (chemical engineering students). These are all only slightly lower than previous marks and marks from the proceeding semesters. The graphical representation is depicted in Figures 31 and Figure 32.

Figure 31



The students from both disciplines performed poorly in the second semester of 1994 and the first semester of 1995 when compared to the overall performance of students throughout the years 1992 to 1997. Hence the successful ex-Access Course students did not perform as well as students from practically orientated bridging courses.

Figure 32



The actual average mark (%) achieved by the students in the first formal level is normally between 50% and 60%. However there is a decrease in the average marks obtained by students originating from the Access Course semesters (1994/1995).

The lower results achieved in second semester 1994 and first semester 1995 indicate that the change in the bridging course in 1994 did have a somewhat detrimental effect on the performance of the students in the first formal level they entered.

7.5.1.2 formal level **Ex Pre-Technician and ex-Access students performances at the S1 (Chemistry I Practical)**

This section analyses the Chemistry Practical results for all formal first level students registered for the National Diploma in Analytical Chemistry or Chemical Engineering.

The results collected by the writer from 1992 to 1997 are displayed in Table 16 and compare the performances of students from the 'old' Pre-Technician Course with the performances of students who completed the Access Course successfully.

TABLE 16 FORMAL COURSE FIRST LEVEL (T1 OR S1) CHEMISTRY PRACTICAL RESULTS 1992 - 1997

S1 Chemistry Practical (Analytical Chemistry)		**S1 Chemistry Practical (Chemical Engineering)**	
1992 sem 1	12 wrote 12 passed (100% passed) 76% ave mark	**1992 sem 1**	54 wrote 54 passed (100% passed) 70% ave mark
1992 sem 2	18 wrote 17 passed (94% passed) 62% ave mark	**1992 sem 2**	21 wrote 21 passed (100% passed) 72% ave mark
1993 sem 1	18 wrote 18 passed (100% passed) 65% ave mark	**1993 sem 1**	25 wrote 20 passed (80% passed) 60% ave mark
1993 sem 2	21 wrote 21 passed (100% passed) 66% ave mark	**1993 sem 2**	47 wrote 42 wrote (89% passed) 59% ave mark
1994 sem 1	29 enrolled 25 passed (86% passed) 53% ave mark	**1994 sem 1**	52 enrolled 44 passed (85% passed) 52% ave mark

1994 sem 2	20 enrolled 18 passed (90% passed) 59% ave mark	**1994 sem 2**	69 enrolled 57 passed (83% passed) 52% ave mark
1995 sem 1	36 enrolled 23 passed (64% passed) 54% ave mark	**1995 sem 1**	63 enrolled 53 passed (84% passed) 57% ave mark
1995 sem 2	26 enrolled 26 passed (100% passed) 61% ave mark	**1995 sem 2**	66 enrolled 62 passed (94% passed) 65% ave mark
1996 sem 1	30 enrolled 29 passed (97% passed) 71% ave mark	**1996 sem 1**	75 enrolled 73 passed (97% passed) 67% ave mark
1996 sem 2	31 enrolled 30 passed (97% passed) 72% ave mark	**1996 sem 2**	70 enrolled 69 passed (99% passed) 66% ave mark
1997 sem 1	22 enrolled 20 passed (91% passed) 68% ave mark	**1997 sem 1**	53 enrolled 52 passed (98% passed) 65% ave mark
1997 sem 2	15 enrolled 12 passed (80% passed) 59% ave mark	**1997 sem 2**	47 enrolled 47 passed (100% passed) 74% ave mark

7.5.1.2.1 Discussion

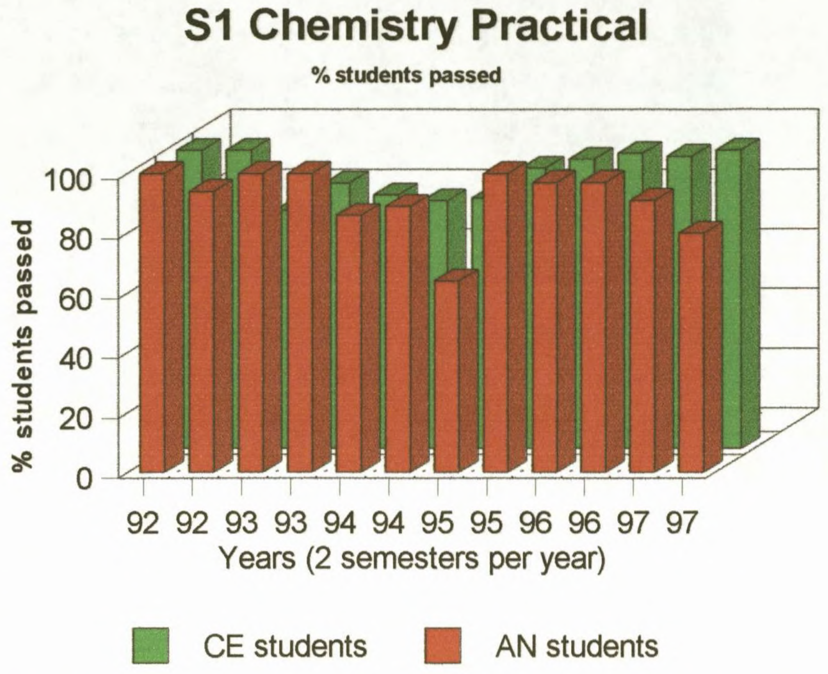
The pass-rate for practical work and the average mark for practical work is lowest over the 1994 and 1995 periods. The absence of practical work in the Access Course was seen to be a problem for the students in the S1 level according to the lecturers questioned by the writer (see Chapter Three). The performance and capabilities of the ex-Access Course students according to the lecturers was *below par*. These students were questioned by the writer (see Chapter Three) and they, too, expressed difficulty in coping with practicals in the formal course.

The assessing of practical work however is another area of contention. Students are assessed on written work only and it is only in a test that some lecturers will give marks for actual laboratory practice. Students tend to work together on practical reports for submission and marking and in some cases actually copy reports from previous students. This scenario has been attended to in recent years by lecturers who feel strongly about such behaviour. Laboratory reports are given back to students for their perusal only and are then collected by the lecturer once more to prevent the reports circulating for future use.

It must also be remembered that Access Course students who were successful in reaching S1 were a small minority (approx 34% of the total students enrolled) so the writer is of the opinion that those students were hardworking and conscientious (they had managed to survive the Access Course which had little in the way of motivation) and were probably likely to succeed. It is the writer's suggestion that more emphasis be placed on student performance in the laboratory as that would be a fairer reflection of how they are coping with concepts and techniques introduced to them. The inferences are clearly discernible in the following graphical representations.

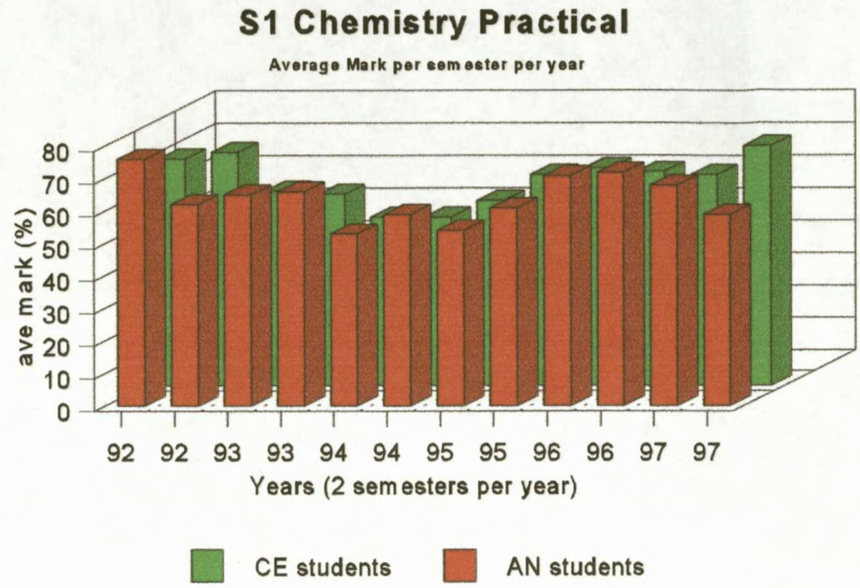
Figure 33

The drop in pass rates of students in both disciplines is evident over the 1994/1995 period (which included students originating from the general Access Course). Interestingly the pass-rate of students in the second semester of 1995



(which included successful students originating from the re-introduced practically orientated Pre-Technician Course in the first semester of 1995) is one of the highest. It is the writer's opinion that all the role players in the Chemistry and Chemical Engineering departments were highly motivated by the reintroduction of a worthy bridging course which most of them had fought hard to have reintroduced. This motivation or impetus achieved the desired results. It should be noted here that bridging course practical work is carried out mainly by dedicated qualified chemical technicians who take pride in the teaching of practical work. If they had been frustrated during the previous year by not being able to offer students hands-on experience, the reintroduction of the practical work in the bridging course would have been greeted with much enthusiasm.

Figure 34



This graphical representation of the students actual average marks (%) for Chemistry I practicals does show a downward trend over the relevant semesters of 1994/1995. Once again the marks improve over the succeeding semesters.

7.5.2 CONCLUSION

The bridging course prior to 1994 resulted in an average of 75% of students being able to access formal tertiary education. The course was, thus, successful for a majority of the students. However, the Access Course of 1994 resulted in fewer than 40% of the students being able to enter tertiary education. The majority of students who could not enter formal tertiary education because of dismal matriculation results did not, therefore, benefit from the Access Course. The pass-rates for bridging course students who entered the formal courses after 1994 increased once more.

The performances of all the successful bridging course students in the formal S1 course have been graphically depicted above. It is clear that the performances of ex-Access Course students in the Chemistry I subject at S1 levels were slightly worse than the ex-Pre-Technician Course students. Although the trends may not be startling, the writer is of the opinion that with all the previous discussion and argument in this section and the trends which are discernible, the S1 students originating from practically orientated bridging courses performed better than those students from the general (no practical work) Access Course.

7.6 COMPARISON OF THE PERFORMANCES AT VARIOUS FORMAL COURSE LEVELS OF SUCCESSFUL STUDENTS FROM THE PRE-TECHNICIAN COURSE (1989-1990) WITH SUCCESSFUL STUDENTS FROM THE ACCESS COURSE (1994).

7.6.1 INTRODUCTION

This section compares the performances of successful ex-Pre-Technician Course students during the formal course with the performances of ex-Access Course students during the formal course.

A random sample of the results of 100 students who registered in the school of Chemistry and Chemical Engineering over the period January 1988 to July 1989 was collected by the writer and a colleague (initially aimed at proving the validity and relevance of the bridging course). Later the writer collected data concerning all 290 Analytical Chemistry and Chemical Engineering students registered for the Access Course during 1994.

The performance of successful ex-Pre-Technician Course students and the performance of ex-Access Course students was monitored throughout the formal course.

The tabulated results below compare students' performances during the formal course levels. The students who originated from the practically orientated Pre-Technician Course are compared with those students who originated from the 'general' (no practical work) Access Course.

TABLE 17 TRACING THE PERFORMANCE OF SUCCESSFUL BRIDGING COURSE STUDENTS THROUGH THE VARIOUS LEVELS OF THE FORMAL COURSE

BRIDGING COURSE (BC)		ACCESS COURSE (AC)		
AN CHEM & CHEM ENG 100 students			AN CHEM 149 students	CHEM ENG 141 students
PASSED BC	75% of the students enrolled, passed	PASSED AC	30% of students enrolled passed	35%of students enrolled, passed
PASSED T1	83% of the students enrolled, passed	PASSED S1	76% of students enrolled,passed	80% of students enrolled, passed
PASSED T2	50% of the students enrolled, passed	PASSED S2	56%of students enrolled, passed	78% of students enrolled, passed
		PASSED S3	63% of students enrolled passed	84% of students enrolled, passed
PASSED ENTIRE COURSE ON FIRST ATTEMPT	42% of the students enrolled, passed	PASSED ENTIRE COURSE ON FIRST ATTEMPT	40%of students enrolled,passed	49% of students enrolled, passed

TABLE 18 ANALYSES OF THE ATTRITION RATE OF STUDENTS WITH RESPECT TO THEIR INITIAL REGISTRATION INTO A BRIDGING COURSE

Note: The % figures show the attrition rates

BRIDGING COURSE (BC)		ACCESS COURSE (AC)		
AN CHEM & CHEM ENG **100 students**			AN CHEM **149 students**	CHEM ENG **141 students**
PASSED BC	25% of 100 students enrolled failed	PASSED AC	60% of 149 students enrolled failed	65%of 141 students enrolled failed
PASSED T1	38%of initial 100 students failed	PASSED S1	77% of initial 149 students failed	72% of initial 141students failed
PASSED T2	69%of the initial 100 students failed	PASSED S2	87%of initial 149 students failed	78% of initial 141 students failed
		PASSED S3	92% of initial 149 students failed	82% of initial 141 students failed
PASSED ENTIRE COURSE ON FIRST ATTEMPT	87% of the initial 100 students failed	PASSED ENTIRE COURSE ON FIRST ATTEMPT	97%of initial 149 students failed	91% of initial 141 students failed

The Table shows the differences in the percentages of unsuccessful students. The high attrition rate of the Access Course compared to the final attrition rate of 87% for the 'old' Pre-Technician Course indicates clearly the technikon's losses in resources and finances, as the ensuing losses incurred by students and their families.

7.6.2 DISCUSSION

The bar graph below serves to indicate that at the initial **bridging course** level the greatest success was achieved by the Pre-Technician Course students. It is quite clear that the Access Course (Acc) pass rate was dismal. The results of successful bridging students in the **first formal level (T1/S1)** are similar and the pass rate is high for both sets of students (the Pre-Technician pass-rate marginally higher than the Access group pass-rate). The results of the successful students at the **second level (T2/S2)** show that the pass-rate of the Access- Chemical Engineering students was higher than their Analytical Chemistry counterparts **and** the Pre-Technician students. It must be remembered however that the second formal level for the Chemical Engineers is not as practically demanding, compared to the course followed by the Analytical Chemistry students. Chemical Engineering students only participate in one general chemistry practical at the S2 level whereas the Analytical Chemistry students participate in five separate practical sessions. The **S** courses have four levels whereas the previous **T** courses only had three levels so **T3/S3** cannot be compared.

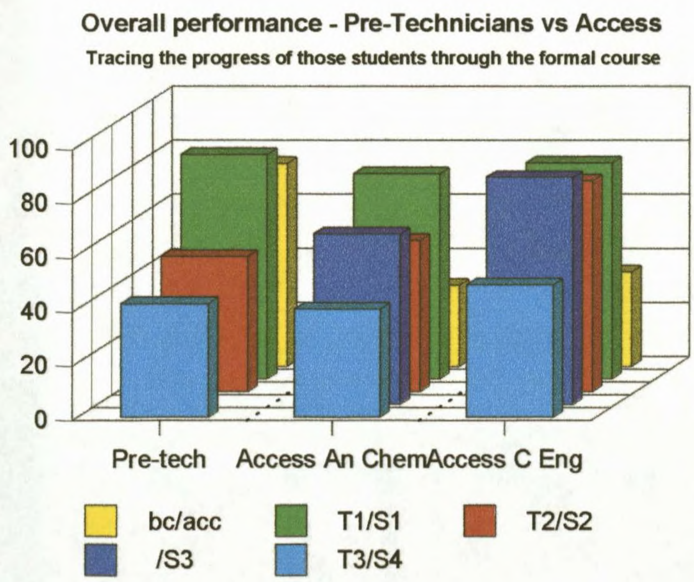


Figure 35

The **final level (T3/S4)** however is comparable and once again the Pre-Technician students performed better than the Access Analytical Chemistry students on their first attempt whereas the Chemical Engineers from the Access Course performed slightly better than all the other students. It is important to note that, aside from the first level, Chemical Engineering students do no pure chemistry practicals. The Chemical Engineering practicals in addition do not carry the same weight as the Analytical Chemistry practicals. The subject-specific practicals are registered subjects in the S2 to S4 levels i.e Analytical Chemistry Practical II and Analytical Chemistry Practical III.

Performances at the first formal course level, by both sets of students who were successful at the initial bridging course level, appear to be similar. (That phenomenon is discussed in the conclusion to this chapter).

The Chemical Engineering students appear to outperform the Analytical Chemistry students throughout the formal course. Consequently, if the initial sample of 100 used from the Pre-Technician Course had been split into Analytical Chemistry and Chemical Engineering students, the writer is of the opinion that similar trends in the performances of the two fields would have been found. It has also been the writer's experience over the years at this technikon, that Chemical Engineering students perform slightly better that Analytical Chemistry students. That is most likely a result of students with better secondary education normally choosing the Chemical Engineering Diploma rather than the Analytical Chemistry Diploma. Another interesting factor which the writer has experienced and which could be researched later is that males tend to enter the chemical engineering field and that black males appear to perform better than their female peers in this field.

7.6.3 CONCLUSION

The writer is satisfied that Chapter Seven presents a fair reflection of the accomplishments of the various bridging courses that have been in operation at Mangosuthu Technikon.

The success of the practically orientated bridging courses in respect of improvement on matriculation results has been discussed, and matriculation Physical Science and Mathematics results were compared with bridging course Chemistry and Mathematics results. The performances of aspirant chemical technicians during the practically orientated bridging course have shown general improvement on the results they obtained in the matriculation examinations.

By comparison, the non-practically orientated Access Course, which was a chalk and talk year for the students, produced only slight improvements on the matriculation grades. The practically orientated Pre-Technician Courses prior to 1994 and after 1994 produced greater improvements than the Access Course (1994) did.

The success of the bridging courses in respect of students progressing into the formal/mainstream Diploma Course has been analysed. The Pre-Technician Course (1989/1990) proved most successful, producing a 75% pass-rate which meant those students could access formal tertiary education. However, the Access Course (1994) was unsatisfactory in that respect. Insufficient of its students were able to access tertiary education. There appears to be a growing improvement with the re -introduction of the Pre-Technician Course (1995 onwards).

The success of the bridging courses in respect of student performances in the major subjects (Chemistry, Mathematics and Physics) at the bridging course level has been analysed. The performances of students in the major subjects in the Pre-Technician Course prior to 1994 were satisfactory, but the dismal student performances in the Access Course were clearly shown. The percentage pass rate for the relevant major subjects dropped in 1994 and the percentage pass rate of students who passed all their subjects also dropped substantially in 1994. The re-introduction of the practically orientated Pre-Technician Course in 1995 and onwards has produced significantly better results.

The success of the bridging courses in respect of student performances in the major subjects (Chemistry Theory and Chemistry Practical) at the T1 or S1 level (first formal level) has been analysed. The results over the years were fairly constant, but a drop in the pass-rate and a drop in average marks obtained by the students in the semesters following on from the Access Course were both evident.

The comparison of performances of successful students from the Pre-Technician Course (1989/1990) and the successful students from the Access Course (1994) in the various formal course levels has been investigated. The main feature of this analysis was that the initial pass rate into the formal course was high for the Pre-Technician Course (75%) but lower for the Access Course (33%). The pass-rate of students from the first level of the formal course to the second level showed that the Pre-Technician Course was somewhat more successful (83% pass rate) than the Access Course (78% pass rate). The second level pass-rate showed the Access Course students performing slightly better (56% pass-rate for Analytical Chemistry students and 78% for Chemical Engineering students) as opposed to the pass-rate of Pre-Technician Course students (50%). Although the number of students who passed the entire course on the first attempt is relatively similar for both courses, it must be emphasised that the introduction of S courses as opposed to T courses has resulted in a spread of subjects over the relevant semesters. That format also allows students the opportunity of carrying subjects and rewriting those subjects at a more opportune time. The students can be promoted to a higher level even if course(s) are outstanding.

The calculation of the attrition rates clearly shows that the Access Course was not successful. The 87% attrition rate for the practically orientated Pre-Technician Course is somewhat better than the 97% (Analytical Chemistry) and 91% (Chemical Engineering) attrition rates from the non-practically orientated Access Course

Although the practical abilities of students have not been assessed to a large degree in this particular chapter, the writer has noted in Chapter Three that staff and students have admitted that students who originated from the Access Course have performed poorly and with difficulty at the first formal level. The same has not been said of the students who successfully completed the practically orientated Pre-Technician Courses.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8

8.1 RECAPITULATION

The study proposed to identify the place of practical laboratory work in the training of chemical technicians at technikons in South Africa. It also proposed to evaluate the methodological importance of practical laboratory work in the education of chemical technicians.

Chapter One stated that Mangosuthu Technikon, at which the study is centred, provides mainly for students whose educational background has ill-prepared them for the demands of tertiary studies. Besides their language disadvantage in English, students in Engineering schools are further hampered in their studies by having inadequate practical skills for laboratory work. Black pupils overwhelmingly, have received inferior education to their white counterparts and as a result are poorly prepared for tertiary studies. From 1989 to 1997, only a relatively small number of black pupils (educationally disadvantaged), wrote Senior Certificate examinations and actually passed with matriculation exemption, which would allow possible access to tertiary education. The need to redress the lack of access to tertiary education has resulted in the introduction and continued use of bridging courses for educationally disadvantaged students.

Mangosuthu Technikon has offered a school/discipline bridging programme (Pre-Technician Course) for the Engineering schools. The course allowed disadvantaged students a second chance to access tertiary education. In 1994 a general Access Course replaced the former Pre-Technician Course. This change was in the interests of rationalisation (i.e. for financial reasons). The emphasis fell largely on the theoretical rather than on the practical aspect. Preliminary research indicated that the role of practical laboratory work in the training of chemical technicians in technikons in South Africa was of consequence, and a practically orientated bridging course was reintroduced in 1995.

Detailed research into the role of introductory practical laboratory work in the success of vocationally orientated students at technikons in South Africa has been presented. An evaluation of the preceding Pre-Technician Course, the 1994 general Access Course and the subsequent Pre-Technician Courses of Mangosuthu Technikon has also been presented.

8.2 THE HYPOTHESES

The original hypotheses (see Chapter One) to this dissertation are reiterated below, with the findings, conclusions and recommendations relevant to each.

8.2.1 HYPOTHESIS 1

Mangosuthu Technikon, will develop suitable bridging courses through improved articulation with the surrounding community.

8.2.1.1 Introduction

Chapter One shows that disadvantaged South African students wanting to follow a career as chemical technicians face problems as a result of being inadequately prepared for tertiary studies. Chapter Two focuses on the recognition of the importance of practical laboratory work for the aspirant chemical technicians (in particular those students who hail from disadvantaged schooling with few or no practical facilities). Chapter Two considers Mangosuthu Technikon's involvement with the community in respect of practical laboratory work for such students. Mangosuthu

Technikon recognised the problems these aspirant students would encounter upon entering the technikon and introduced bridging courses throughout the Engineering departments. Chapter Three clearly shows that practical facilities at secondary schools are lacking for aspirant black chemical technicians. That is reaffirmed in Chapter Five.

8.2.1.2 Discussion

The writer endeavoured to show in Chapter Two the dismal educational system from which the majority of Mangosuthu Technikon's aspirant chemical technicians have come. In Chapter Five (Section A), questionnaire responses from aspirant chemical technicians enrolled at technikons in South Africa are documented. Those responses show that the secondary schooling of the majority of the respondents did not adequately prepare them for the tertiary education they were trying to access (see Chapter Five, Section C). The responses confirmed high numbers of students in science classes and inadequate facilities for science teaching and practical work. The students had also had very little opportunity for hands-on practical work and in some cases no practical work at all. The expressed desire for hands-on experience and practical work by aspirant chemical technicians was noted in Chapter Two. Chapter Three debates the role of hands-on experience for aspirant chemical technicians, and concludes that practical work enhances both the independence of the student and the desire to explore.

In Chapter One the writer finds that those aspirant chemical technicians who did not have the opportunity of practical work during the bridging course and then went on to the S1 level did not cope well with practical work in the formal course. That was confirmed by students and lecturers. Other aspirant chemical technicians, who attended a practically orientated bridging course, stated that they coped with practical work in the formal course and that was confirmed by the lecturers.

It would appear that practical laboratory work fulfills an important function of the course, and satisfies desires for hands-on experience.

Chapter Five (Section C) considered the questionnaire responses of technikon personnel involved with the bridging courses and formal courses for chemical technicians at technikons in South Africa. The technikons without exception considered practical work desirable for bridging courses pertinent to chemical technicians. Their opinions of the practical abilities of such students on entering their technikons were unanimous and confirmed that "students entering the bridging course have very little if any experience in practical work". Such responses confirm that practical work has an important role to play in students' tertiary studies. Responses also confirm institutions, staff and students are fully committed to success via the inclusion of practical work. Such responses reiterate the desirability of practical tuition and its importance in the training of technicians.

From the responses documented it would appear that the objective of including practical work in chemical technicians' courses is to familiarise students with laboratory work and laboratory equipment through teaching manipulative, observational and measuring skills. It was also stated that practical work developed and honed students' practical laboratory skills by providing hands-on experiences of science in action. Students, thus, made use of their senses to gain knowledge. Practical laboratory work included in the bridging courses (and the formal courses) also allow the students to make sense of theoretical linkages. Practical tuition should be seen as an integral component of science teaching, while the relation of this type of tuition to theory, and its relevance to industrial processes, must also be stressed.

Course objectives seem to be assessed continuously throughout all technikons' courses, by evaluation of students during practicals, assessments of write-ups handed in after each session, and finally through practical tests or examinations at the end of each course. Responses showed also that practical course work was evaluated and updated to keep abreast of changing times. Such deep commitment to course assessment, evaluation and updating would appear to confirm the importance of practical work in the education of chemical technicians.

Chapter Two indicates that active learning lays down schemata for students' future learning. The inclusion of practical work linked with theoretical learning allows the student active participation and learning through discovery. Throughout Chapter Two practical tuition is shown to be important. Laboratory work obeys the principle of experience as well as exploration. The importance of linking theory and practical work is to be stressed if students are to be adequately and relevantly trained for the demands of industry. Courses should focus on those demands, to ensure that students satisfy the needs of employers.

8.2.1.3 Conclusion and Recommendations

Chapter Five discusses aspirant chemical technicians' comments on the worth of their bridging course. The four technikons that answered were unanimous that comments from students were favourable. Since the secondary education system is not improving substantially it would appear that bridging courses will remain a necessity for some time. The curriculum development of such courses should be ongoing and involve secondary schooling experts as well as personnel from the formal courses. That would ensure a relevantly designed curriculum, rather than one which merely repeats matric work or attempts to provide a "quick fix" option. The Schools Liaison Departments of each technikon should work to improve technikon/schools communications so that appropriate tuition (theory and practical) may be given in bridging programmes. The enjoyment of practical work and its relevance to such a course has been manifested herein. The technikons who responded to the questionnaire, as well as the representatives from industry, confirmed that bridging courses have an important role to play in ensuring that disadvantaged students access tertiary education successfully. Both sets of respondents affirmed their commitment to practical work as a necessary inclusion in bridging course content. Practical work is seen to enhance the credibility of a bridging course and satisfies the needs of aspirant chemical technicians and the demands of their future employers.

8.2.2 HYPOTHESIS 2

The emphasis on practical laboratory work for technicians in technikons will need to be maintained in bridging programmes.

8.2.2.1 Introduction

Practical work is important in allowing a disadvantaged student a chance to access the particular type of tuition which he has previously been denied. Chapter Five surveys the technikons which offer bridging courses for aspirant chemical technicians and shows the importance of practical work within the courses. The majority of technikons stated that the practical component had to be passed in order to pass the Chemistry course. Two technikons actually needed the practical component to be passed in order that the entire course be passed. The pass rate for aspirant chemical technicians who enrol in practically orientated bridging courses in South African technikons was found to be between 40% and 80%. This confirms that those students who would not otherwise have been able to access formal tertiary education were, consequently, successful in doing so. Other responses show a need for practical work to be included and maintained in the bridging courses. Such responses indicate that institutions are committed to ensuring students are adequately trained technicians (i.e. that they are competent in the practical skills of the course and have sufficient theoretical knowledge to be able to cope with the demands (ultimately) of industry). Theoretical knowledge alone is insufficient for a chemical technician.

8.2.2.2 Discussion

The overview expressed above is corroborated by student comment. When a student who had completed the School specific Pre-Technician Course was asked whether the practical sessions were important, the answer was as follows:

> *"Yes. On reaching S1 from Pre-tech I was familiar with and used to the laboratory work which made work a bit easier. The practicals help you right through to the industry. As I reached S1 from Pre-Tech I already had a good foundation".*

A student who had enrolled in and completed the general Access Course was asked:

> *Did you feel this was a disadvantage? (lack of chemistry practical classes)?*

The response was:

> *"Yes because when we first do practicals it was too difficult because we didn't know what to do. We didn't know even the functions of the equipments"* (sic)

It claimed herein that practical work is a pre-requisite to being a successful technician. If practical work is stressed, the credibility of the course work increases. Responding to a questionnaire in 1995 (see Chapter One), students display a positive attitude to practical work, indicative of most of the students enrolling for technician programmes:

Were practical sessions important?

84 YES/13 NO

Did you enjoy them?

96 YES

Do you think they are important for your future studies?

97 YES/1 No

Student pass rates (see Chapter 5), show the success of bridging courses. In formal courses, the performances of students who had the advantage of practical work during a bridging course show that practical work has a positive and significant role to play (see also Chapter 7).

8.2.2.3 Conclusion and Recommendations

Findings throughout the dissertation show that practical work is of consequence. The writer recommends that laboratory work be incorporated into lectures so that students are encouraged not only to learn theory, but also to integrate it with practical work. It is important that practical work be emphasised by curriculum developers and other role players. Practical work should be assessed in earnest and marks weighted accordingly. Practical work should also be emphasised in student handbooks, thus creating an awareness among students of the important role that practical work will play throughout the course.

8.3.3 HYPOTHESIS 3

Industry will favour the inclusion of relevant practical tuition in the education of chemical technicians.

8.3.3.1 Introduction

Industry's input on the relevance of practical work is minimal. Chapter Five shows that industry has little input or influence regarding the practical course content. Based on her experiences and on interviews with the relevant representatives from industry, the writer recommends that industry be involved in the design of the practical component — and, where necessary the theoretical component — of an integrated curriculum for aspirant chemical technicians. As Chapter Six indicates, industry favours some sort of input or influence into the courses for potential experiential students.

8.3.3.2 Discussion

Personnel in industry emphasises that practical chemistry work should focus primarily on relating theoretical knowledge to practical applications and secondly on instrumentation and wet chemistry techniques. The common problems that students present on entering the industrial field are language and poor or limited communication skills (see Chapter Two). The inclusion of relevant communication work in the practically orientated bridging courses for chemical technicians will assist in alleviating such problems.

Industry also favours the idea that project work related to industrial demands/processes be introduced to enhance a course (see Chapter Five). In that regard the writer has established that bridging courses impact on formal courses (see Chapter Seven) and as a result, formal courses would need to assess not only format, but also content, if they are to meet the demands of industry.

8.3.3.3 Conclusion and Recommendations

The Department of National Education is clear in its objectives for tertiary institutions. The objective of technikons is to prepare students for a particular occupation or industry (refer NATED 02-150 94/01:vii). Courses offered by technikons are well planned and developed, to ensure that the objectives for each course are realised.

Technikons implement and administer courses which will allow a student to become a part of the working community. Course content is therefore, influenced by the needs of students and the demands of employers.

DACUM (Develop A Curriculum) is an initiative introduced throughout South Africa as a result of linkages between Canadian Colleges and South African technikons. According to Mr J Tromp of Peninsula Technikon, wherever it has been introduced it has been well received. Its introduction to technikon/industry liaison would be beneficial, since it can "help identify certain groups of related skills required by industry and design a competency/skills based set of modules to suit the needs" (in Reaching Out, 1995:8).

8.3 RECOMMENDATIONS

It is hoped that these recommendations may facilitate the design of bridging courses that purposefully relate effective teaching and learning principles (after Scott, 1994) to the curriculum and its objectives holistically.

* Even if bridging courses are centrally curriculated, commitment to a course must be a priority. If post-matriculants are to be encouraged to attend such courses focused on science and technology, the "quality of instruction and applied

industrial research must be high at these institutions" (Centre for Education Policy Development, 1994:3). Not all students are the same, and provision needs to be made for that consideration within a course.

* Selection at technikons is not effective and requires much attention. "... change in selection procedures and techniques is imperative" (Access to Technikon Study, Mangosuthu Technikon, 1995:37). Some recommendations which the writer and colleagues put forward at a Workshop in 1995 were: assessment of students' motivation, interviews, HSRC testing, psychometric testing, testing to be discussed with the student body so as to assure students that the testing is designed not to exclude but include, skills profiles of students' abilities, and career assessments prior to registration. As a result of the imperfections in selection, there should exist greater flexibility within the institution so as to redress the problem of losing potential technicians.

* Bridging course students should have an effective orientation programme.

* Only permanent staff should be involved with the bridging courses and such staff should have had experience in this type of work, since a bridging programme is somewhat different from a formal course. Staff involved with bridging courses are normally contracted to departments. However, staff should be permanent, for the following reasons:

Staff would be able to:

a)commit themselves entirely to the programme

b)be available at all times for student's needs

c)ensure integration with other courses being offered will ensue

d)increase the professional respectability of the course in the eyes of academic colleagues

e)continually assess and evaluate the course

f)refine the existing course and, where necessary, develop new components or courses

For their part, students would then view a course more favourably than as an 'add-on' for below-average students. Courses would move away from deficit models towards truly integrated designs. Communications between staff and students would be enhanced and greater integration within the subject discipline would be achieved.

* Personnel should be available to research design-options — whether to incorporate a course into its formal parent, or to allow some sort of credit-bearing system — so that a course is not perceived as an add-on programme.

* Introduce peer interaction and self help groups. The concepts of Peer Counselling and Cooperative Learning are fast growing in popularity as methods of study and assistance for tertiary students. Two success stories in South Africa, come from Peninsula Technikon, where a Mentoring Peer Assistance Programme has been introduced, and Port Elizabeth Technikon, which has introduced a Peer Support Programme. These have been welcomed, since technikons have limited manpower

and resources to spare for adequate assistance to educationally disadvantaged students, who are increasing in number at tertiary institutions. These types of programmes would be of major benefit to any bridging courses offered by technikons (see Chapter Two).

Johannes A Slabbert had the following to say in his article on "Metalearning and education for all": "Cooperative learning involves more than just putting students together in small groups and giving them a task. It also involves careful attention and thought to various aspects of the group process (Davidson, 1990:1). Students in the small group help one another to enhance the quality of their learning through reflection on the learning process". This type of learning provides a "social support mechanism for learning. Students have a chance to exchange ideas, ask questions freely, explain to one another , clarify ideas and concepts, help one another understand the ideas in a meaningful way and express feelings about their learning. Groups can often handle challenging situations that are well beyond the capabilities of individuals at that developmental stage" (South African Journal of Higher Education, Vol. 8 No 1, 1994:39).

Another positive effect of cooperative learning is that team members become friends. Interpersonal relationships are developed and enhanced, and ongoing communication among team members assists them in the acquisition of language skills.

* Where possible (depending on what facilities are available at an institution) staff should encourage students to make use of the Learning Assistance Centres and Resource centres within their institutions. Computer Managed Learning (CML),

a popular innovative method of learning, is effective in facilitating self paced learning. At Mangosuthu Technikon re-curriculation of some programmes, incorporating the use of CML, is already under way.

Programmes such as the MAESTRO Programme, which focuses on bridging the gap for Mathematics and Physical Science, will be most beneficial to Pre-Technician Courses at all Engineering schools. Microchem kits are another fairly new initiative with which the writer has had the good fortune to be involved. These kits are being used successfully throughout South Africa and in areas abroad. They can also be easily accommodated in a learning assistance centre as the availability of water is the only prerequisite for the practical work designed for these kits.

* Regular use of student demonstrators in the practicals should be encouraged. Senior students should join the tutorial assistant programmes and be employed as demonstrators in Pre-Technician practical courses. Their involvement would encourage and assist new students.

* Personnel should be trained to introduce integrated courses, requiring students to make use of communications and manual skills, as well as thought processes and regular theory learning. Modularisation is an extremely popular bridging course format (Access to Technikon Study, Mangosuthu Technikon, 1995). Modules should include an emphasis on competency based and vocational education. Initial modules could include links with industry thus increasing students' career insights.

* Shared core subjects would assist student mobility between schools/departments and /or technikons. The writer suggests (with acknowledgement to the influence of other colleagues who participated in the 'Access' workshop in 1995) that core subjects for such an integrated bridging course should be: Chemistry, Physics, Mathematics and Life Skills (this particular course could be offered in modular form and cover such areas as learning-skills, time management, use of resources, job hunting skills, careers guidance etc.). English/Communications should be integrated with all the core subject material; it should not exist on its own, and that notion should be extended beyond the bridging course and operate throughout formal courses. Indeed, links among all subjects should be aimed for so as to form a more integrated curriculum.

* To assist students it is suggested that supplemental instruction, computer managed learning, video presentations, reading skills, study skills, peer group systems and integrated theory and practical sessions be incorporated into the course. Computer literacy must be included from ground level, so a Computer Awareness Course must also be provided. This course should be aimed not so much at enabling students to become skilled computer users or programmers, but rather at giving students a broad insight into the ways computers work and are used. Such a course would also allow students to acknowledge what a computer is capable of and what it is not capable of.

* Diagnostic assessment would empower students for their future careers and development. It is also necessary that the teaching and learning in the course be validated. Assessment should be holistic, and encompass student progress assessment, skills assessment, lecturer assessment and needs assessment. The

course should be driven by these. A student's abilities and predicted success should be measured against competence with appropriate technology and in relevant situations. The expectations of industry should be considered when assessing a student and/or course. Remedial steps must be taken when and where necessary so as to complement ongoing assessment. Actual assessment of student performance in the course need not be based on formal examinations but could be more innovative. Assignments, projects, self-made models etc. could be some starting points.

Fransman (1991) states that it is imperative that examinations "evoke that kind of learning which is meaningful and not merely of a reproductive nature"(in South African Journal of Higher Education, Vol.5 No2, 1991). Lecturers need to move away from methods of evaluation that rely on reproduction and rote learning. Assignments, for example have the potential to elicit more meaningful learning.

Assessment of students should become a priority as it impacts throughout a programme and not just on a particular course. Assessment is ... "a process which should be all inclusive" (Access to Technikon study, Mangosuthu Technikon, 1995). Beasley (1991) argues in his paper that students should perceive laboratory work as more than a confirmation of lecture material. According to Beasley the laboratory programme is representative of the activities with which a chemist is involved. The assessment of the student in such programmes should be such that it "takes a developmental approach and continually shapes students skills toward outcomes more congruent with being a chemist" (in Journal of Chemical Education, July 1991:591)

* Six months' duration for a course which is aimed at redressing so many problem areas is too short a period. A six-month course effectively runs for only twelve to fourteen weeks, and not for twenty-four weeks. However, if the duration is extended, accreditation for the course would be imperative. If it were included as part of a formal course, it would allow a firm foundation from which to launch a potential chemical technician. If, however, the course remains a separate entity, it is imperative that a coordinator be appointed to it. The coordinator would have to be a fulltime appointee and be accessible to both staff and students. Evaluation of the course and course materials would be the responsibility of the coordinator and the relevant staff involved with the course.

8.4 RECOMMENDATIONS FOR FURTHER RESEARCH

8.4.1 Mathematics and Physics

The writer has investigated the role of practical work in the training of chemical technicians at South African technikons. Chemistry theory and Chemistry practical work in the formal courses were also investigated. The writer recommends that other subjects, particularly Mathematics and Physics, be investigated. That would ensure that only relevant subjects are incorporated into bridging courses.

8.4.2 Male vs Female in respect of subject choice and performance

More men than women select a career in Chemical Engineering (see Chapter Seven). It would be advantageous to research that factor more fully, to enable career guidance teachers opportunities to work effectively on that imbalance. Industry would also gain thereby.

The comparative performances of men and women in the Chemistry and Chemical Engineering fields would be interesting to research. Findings might enable academics to revisit the curriculum and teaching methods so as to address/redress this factor.

8.4.3 Performance of Chemical Engineering students vs Analytical Chemistry students

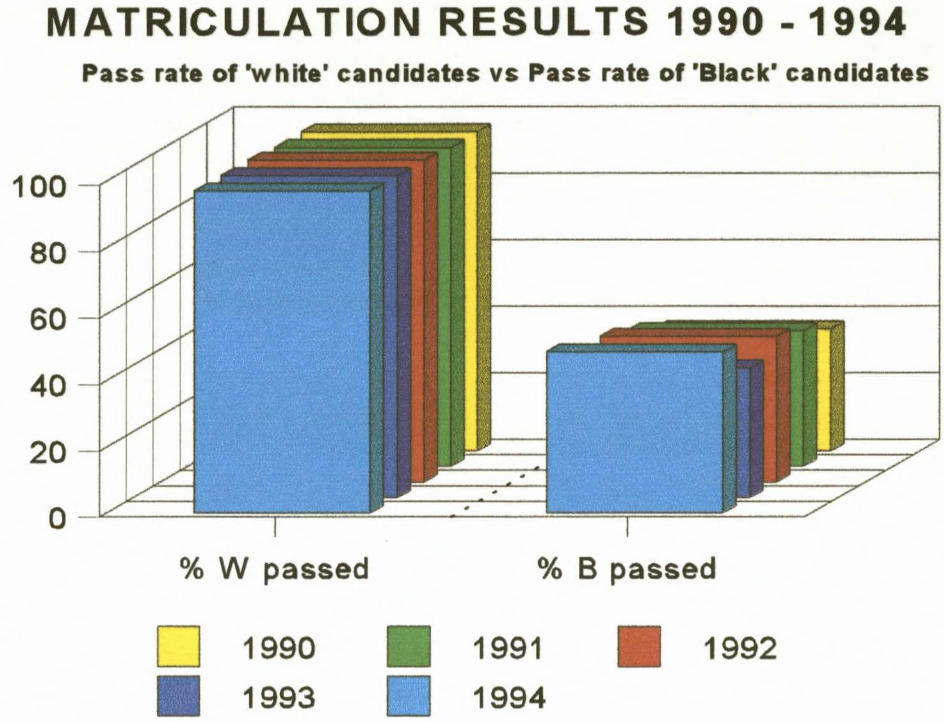
Another unforseen finding of this study is the difference between the performances of Chemical Engineering students and Analytical Chemistry students. It would be advantageous to course developers to ascertain the full nature of that difference.

8.5 CONCLUDING REMARKS

A chemical technician works with hands and mind thus emphasising the need for hands-on experience. A technician is one who is skilled in a mechanical art - the combination of theoretical knowledge and practical skills is a pre-requisite for success. An educationally disadvantaged student who aspires to a chemical technician requires an holistic education, incorporating relevant theoretical and practical components in order to achieve success at the bridging course level, thereby procuring entry to, and maximal benefit from, a tertiary education.

> **If we can leave our students with a sense of self-confidence in their ability to tackle scientific problems and have stimulated them by the fun and challenges of science, we will have equipped them with vision and a pair of stout walking boots, well prepared to deal with the next unexpected challenge (Woolnough, 1991:188)**

Appendix 1


MATRICULATION RESULTS 1990 - 1994
Pass rate of 'white' candidates vs Pass rate of 'Black' candidates
100
80
60
40
20
0
% W passed
% B passed
1990
1991
1992
1993
1994

Appendix 2

Standard 10 examination results for all population groups, 1989 - 1994

Year	Candidates	Blacks	Whites	Coloureds	Asians	Total
1989	Number	209 139	70 666	22 666	14 191	316 842
	Pass:Matric Exemption	21 357	29 933	4 044	5 889	61 223
	Pass:S-l Certificate	66 153	37 892	12 431	7 393	123 869
	Total pass	87 510	67 825	16 475	13 282	185 092
1990	Number	255 498	68 097	22 315	14 542	360 452
	Pass:Matric Exemption	21 025	27 986	4 656	6 614	60 281
	Pass:S-l Certificate	72 837	37 269	13 661	7 201	130 968
	Total pass	93 862	65 255	18 317	13 815	191 249
1991	Number	304 315	67 490	22 405	14 258	408 468
	Pass:Matric Exemption	33 330	27 751	4 911	7 062	73 054
	Pass:S-l Certificate	91 013	37 064	13 646	6 630	148 353
	Total pass	124 343	64 815	18 557	13 692	221 407
1992	Number	342 038	67 549	24 419	14 485	448 491
	Pass:Matric Exemption	35 357	27 968	5 120	7 156	75 601
	Pass:S-l Certificate	114 624	37 740	15 994	6 568	174 926
	Total pass	149 981	65 708	21 114	13 724	250 527
1993	Number	366 501	65 019	25 735	15 203	472 458
	Pass:Matric Exemption	29 517	27 030	5 411	6 862	68 820
	Pass:S-l Certificate	113 570	36 229	16 666	7 025	173 490
	Total pass	143 087	63 259	22 077	13 887	242 310
1994	Number	392 434	62 507	25 375	15 092	495 408
	Pass:Matric Exemption	49 239	26 057	5 562	7 639	88 497
	Pass:S-l Certificate	141 101	34 764	16 639	6 342	198 846
	Total pass	190 340	60 821	22 201	13 981	287 343

Results of suppplementary examinations not included.

Appendix 3
Passrate (%) and number of passes of Std 10 candidates per province, 1995

PROVINCE	% PASS RATE
Northern Cape	75
Free State	51
Mpumalanga	42
North West	67
Western Cape	84
Eastern Cape	48
Gauteng	64
Northern Province	39
Kwazulu Natal	77

Appendix 4

Questionnaire given to Pre-Technician students in 1995.

Dear Student,

Attached please find a questionnaire which I would appreciate you answering. I am collecting data concerning Pre-technicians who enrol at this technikon. The data will assist me in my endeavours to write up a thesis for the Masters Diploma in Technology.

1. What school did you matriculate at?

   1.1 State your symbol for English/Maths/Science

   E...............M...............S...............

2. Did you have a qualified science and maths teacher?(in Std 9 and 10)

   Yes/No

3. Did you have facilities at the School for Practical Science tuition?

   Yes/No

4. Were you able to get "hands-on" experience with practical work?

   Yes/No

5. Were demonstrations only available? Yes/No

6. Would you have liked your school to have been involved with the Technikon or a technical college so as to allow you greater access to practical tuition?

   Yes/No

7. Do you think it would have helped you in further studies?

   Yes/No

8. What year and semester (January/July) did you start at Mangosuthu Technikon?

9. What do you think such a bridging course as this Pre Technician's programme should achieve?

   9.1 As a pre-tech access student; did you feel a part of the technikon campus life?

   Yes/No

   9.2 Were your lecturers involved with the formal courses as well?

   Yes/No/Unsure

   9.3 Did the lecturers encourage you with your studies?

   Yes/No

   9.4 Were lecturers readily available for extra help if you needed it? Yes/No

10. Were the practical sessions important? Yes/No

10.1 Did you enjoy them? Yes/No

10.2 Do you think they are important for your future studies? Yes/No

10.3 Did you think the use of student demonstrators to assist with practical tuition was a good idea? Yes/No

10.4 Would you like to be involved with such work when you reach the appropriate level? Yes/No

For all students to answer:

11. The bridging programme should be an important part of your future study progression. At the least it should span 6 months otherwise 12 or even 24 months is envisaged. The bridging courses on offer at Mangosuthu Technikon are 6 month courses........is this sufficient (keeping in mind that in reality the courses are much less than this)? Yes/No

12. Would you prefer the pre-technician's programme to be:

a)incorporated into the formal course (i.e. extend the actual diploma course by 6 months)?

b)a separate certificated course?

c)a separate course having subjects with different credit ratings?

13. How did you cope with the practicals?

Easily/some difficulty/much difficulty

14. Were the practicals stimulating/interesting? Yes/No

15. Did you find them relevant? Yes/No

16. Were the practical worksheets...easy/somewhat easy/ difficult .... to follow?

17. What is more preferable for pre prac work: lecture/tutorial

18. Rank in order of importance what you would have wanted extra assistance with:

a)experimental background knowledge/theory

b)interpreting results

c)explanation of equations used in practicals

d)explanation of results

e)advice on report writing

f)manipulation of results

....

19. Rank in order of importance what you consider necessary for greater success of practical work:

a)more practice on equipment

b)greater time spent with demonstrations

c)greater assistance in explaining results

d)more guidance on report writing

e)smaller group sizes

f)oral discussion of problems

g)more practical work

h)greater preparation for the scheduled experiments

....

20. Would you have liked the following incorporated into your practical course:

a)video demonstrations Yes/No

b)computer aided programmes Yes/No

c)more demonstrations Yes/No

WITH THANKS

JANICE LAFFERTY

Control Technician

SCHOOL OF CHEMISTRY AND CHEMICAL ENGINEERING

Appendix 5

Questionnaire given to S1 students (1995)

Dear Student,

I am collecting data concerning the bridging course for chemical technicians on this campus. I would appreciate it if you could answer the attached questionnaire as fully as possible.

Name not necessary

Level:..

What High School did you matriculate at?...

What subjects did you pass in matric (state subject and symbol where possible)

Why did you choose to study maths and science?

If you can remember ....At what levels was Science taught at your School?

How many pupils were involved with science studies in your matric year?

(If you can answer, Please also fill in numbers for other standards)

Did you have a qualified science and maths teacher?(in Std 9 and 10)

What facilities existed at the School for Practical Science teaching?

Were you able to get "hands-on" experience with practical work or were demonstrations only available or did you receive no practical work?(Feel free to elaborate here)

Please write down your feelings about the education system you were a part of.

Would you have liked your school to have been involved with the Technikon or a technical college so as to allow you greater access to practical tuition?

Why?

Why did you choose to study further at Mangosuthu Technikon?

What year and semester (January/July) did you start at Mangosuthu Technikon?

Did you take part in the Pre-technician/access programme?

Was it the School specific(prior to 1994) or the General access programme(1994)?

Please write down your comments about this programme.

What do you think a bridging course should achieve?

As a Pre-tech /Access student; did you feel a part of the technikon campus life?

Were your lecturers involved with the formal courses as well?

Did the lecturers encourage you with your studies?

Were lecturers readily available for extra help if you needed it?

If you were involved with the School specific Pre-tech course then please answer the following:

Were the practical sessions important?

Why?

Did you enjoy them?

Why?

What else would you like to have had included in the practical programme?

Were the practical sessions a good foundation for your future studies?

Why?

What are your views regarding the use of student demonstrators to assist with practical tuition?

Would you like to be involved with such work when you reach the appropriate level?

******If you were a student who was involved with the general Access course then you received no chemistry practical classes.**

Do you feel this was a disadvantage?

Why?

How did you cope with S1 chemistry practicals?

FOR ALL STUDENTS TO ANSWER:

The bridging programme should be an important part of your future study progression. At the least it should span 6 months otherwise 12 or even 24 months is envisaged. The bridging courses on offer at Mangosuthu Technikon are 6 month courses........is this sufficient (keeping in mind that in reality the courses are much less than this)?

Could you make some recommendations for ensuring students do get at least 6 months tuition?

Please comment on the other courses you studied.

Include wether the time allocated for each course was sufficient? Did these courses give you a good grounding for later studies or was it merely a repeat of the matric work?

What do you understand about LIFESKILLS?

Should a course dealing with this be incorporated into the bridging course?

Why?

Would you prefer the pre-technician's programme to be incorporated into the formal course (i.e. extend the actual diploma course by 6 months) or would you prefer the course to carry a certificate or carry credits towards formal studies or would you want the course to remain the same?(Please feel free to write down your comments in full)

I thank you for your cooperation and request that this form is forwarded to me as soon as possible.

JANICE LAFFERTY

Control Technician

SCHOOL OF CHEMISTRY AND CHEMICAL ENGINEERING

Appendix 6

Questionnaire given to S1 lecturers (1995)

To: S1 Lecturers involved with Chemistry Practicals

FROM: Janice Lafferty

DATE: 13 June 1995

SUBJECT: Questionnaire concerning practical work involving students from the Access Course

1. In your opinion were the S1 class ready and able to begin the formal S1 practical programme? YES/NO

   Could the students carry out the first titration without help? YES/NO

   Did they have any understanding of indicators? YES/NO

   Did the students recognise the various glassware? EASILY/SOME DIFFICULTY/MUCH DIFFICULTY/NOT AT ALL

   Could these students use the top pan balances without assistance? YES/NO

   Could these students use the analytical balances without assisstance? YES/NO

2. Were pre-prac talks necesary? YES/NO

3. How much time was spent on these talks? -----min

4. Was this different to any of the previous classes taught? YES/NO

5. Were practicals completed during the specified time? YES/NO

6. Were you able to hand-back practical work with time for explanations?

   YES/NO

   If NOT could you suggest a method to achieve this

7. Did you ever feel the need to repeat any practicals because students had not gained sufficiently from it? YES/NO

8. If YES did you repeat a practical? YES/NO

9. How would you rate the practical performance of these students:

   Excellent/Good/Fair/Poor

10. Were students enthusiatic to learn? YES/NO

11. In your opinion, would the practical work normally done during the Pre-tech programme, have benefited the students?

    YES/NO

    Did the students ever express dissatisfaction with the previous course as it had no practical work included?

YES/NO

If YES could you write some comments in this space PLEASE

....

Compare the practical results of this class to a previous class who had the benefit of the Pre-tech programme with practicals.

State CLASS SEMESTER AND YEAR used for comparison..

What was the average PRACTICAL mark of the previous class?..............

What is the average PRACTICAL mark of this class?...................

Please state the overall pass rate for the semester for this class eg: No in class/ No passed all subjects/ No carrying only one subject /

Any other comments about this particular class's practical abilities must be written here...

....

Many thanks for your co-operation

Janice Lafferty

Control Technician

SCHOOL OF CHEMISTRY AND CHEMICAL ENGINEERING

Appendix 7

A list of Technical Colleges contacted

1. Alexandra Technical College

2. Soshanguve Technical College

3. Border Technical College

4. Mpondozankomo College (Witbank)

5. Umlazi Technical College

Appendix 8

A list of Non Government Organisations contacted

1. LEAF (Leadership Education and Advancement Foundation) College of Commerce and Engineering

2. College of Science (University Witwatersrand)

3. Science Foundation Programme (University of Natal - Pietermaritzburg)

4. PROTEC (Development Organisation to prepare students (from disadvantaged communities) in mathematics and science for careers in Technology)

5. PRISM (An education project to provide a 'second' chance for students to upgrade science and mathematics and enter tertiary education)

6. ASECA (A Secondary Education Curriculum for Adults)

7. RADMASTE Centre (Centre for Research and Development into Mathematics, Science and Technology Education)

Appendix 9

Questionnaire given to Pre-Technicians (1996)

Pre-Technician Questionnaire

Name

Age Male/Female

1. Please give your symbols and grades for the following matriculation subjects:

	Symbol	HG/SG
Physical Science		
Mathematics		
English		
Aggregate		

2(a) Give the name of the school at which you wrote your matriculation examinations

2(b) Give the province in which this school is situated

3(a) Did you conduct any Physical Science experiments **on your own** at school?

Y/N

3(b) If yes where did you conduct such experiments? (Tick those which are applicable)

I)in a laboratory

ii)in an ordinary classroom

iii)outside

iv)other (please specify)

4(a) Did your school Physical Science teacher demonstrate any experiments to you?

Y/N

4(b) If yes, did this teacher demonstrate such experiments:

(Tick those which are applicable)

I)in a laboratory

ii)in an ordinary classroom

iii)outside

iv)other (please specify)

v)to the class as a whole

vi)to a small group of pupils

vii)to individuals

5 How many pupils were there in your Physical Science class?

I)less than 10

ii)between 10 and 20

iii)between 20 and 30

iv)between 30 and 40

v)between 40 and 50

vi)more than 50

6(a) If you answered NO to questions 3(a) and/or 4(a), have you ever been inside a science laboratory? Y/N

6(b) If yes, when and where?

7(a) Did you have a full time Physical Science teacher during your

Standard 9 year? Y/N

Standard 10 year? Y/N

7(b) If NO, give details regarding the amount of time during your standard 9 and 10 years

that you did have a science teacher.

Thank You for your cooperation in completing this questionnaire.

Appendix 10

5.3 REPORT ON INTERVIEWS AT TWO TECHNIKONS

BT: BORDER TECHNIKON 7/10/97
TWR: WITWATERSRAND TECHNIKON 8/10/97

5.3.1 TASK SHEET AND INTERVIEW STRUCTURE

5.3.1.1 MEET WITH STAFF

5.3.1.1.1 Interview staff involved with the bridging programmes.

BT: Interview with Barry Chapman (Head of Tertiary Foundation Course - TFC) and James Valiathazhel (Lecturer for TFC). The course which is practically oriented focuses on practical procedures in Physical Science. "So many of our students in this area come through school systems sorely lacking in either adequate physical science training or laboratory facilities" (Chapman, F&T Weekly, 25 April 1997).

TWR: Unfortunately the visit to the Witwatersrand Technikon was not nearly as organised in terms of availability of lecturers and students for interviews. I did however meet with the Laboratory lecturer Ms Louise McKechnie and a lecturer (Louize Lindeque) from the formal course (S1 chemistry students).

5.3.1.1.2 Explain the purpose of the visit

BT: The two interviewees were presented with a letter of introduction and conversation took place about the purpose of the interview.

TWR: The letter of introduction was given to the interviewee.

5.3.1.1.3 Follow up on anything outstanding from the questionnaires

In particular: obtain record of matric results and, if any, the comparisons of the matric results with final bridging course results (as answered in the questionnaire, question 3.1 and 3.2).

BT: Unfortunately there are no records of matric results for comparison to TFC results.

TWR: Likewise.

5.3.1.1.4 Obtain: copies of the practical manuals

to look at sequence of practicals, their contents and their objectives.

Copies of practical tests and mark schemes. Statistics, where possible, of bridging course students and their follow-on results at the higher formal levels.

BT: Mr Valiathazhel supplied a copy of the practical schedule as well as the end-of-year practical test. Unfortunately no other statistics concerning success or otherwise of the bridging course were available.

TWR: The practical handouts were made available. Unfortunately no statistics concerning the success or otherwise of the bridging course were available.

5.3.1.1.5 General: discuss any common problems or concerns regarding the present course, with particular emphasis on the practical aspect.

BT: Both lecturers were quite adamant that a bridging course of this nature was still needed as the schooling system had not improved a great deal. In fact some students accepted onto the course had Matric symbols as low as GG for Physical Science and Mathematics. Schools were still not very active in practical work. Both lecturers were positive about the success of the course and recalled positive feedback from students as well as formal course lecturers (see 5.3.1.3.3). This bridging course feeds several formal courses and is not specific to one discipline.

TWR: The two lecturers involved expressed mixed feelings. One was adamant that practicals had a positive effect on students and that if they understood practically it assisted with the theoretical understanding. The second lecturer, however, felt that because the bridging course was not focused on Analytical Chemistry (general course for technicians) the students still needed much guidance practically on reaching the formal course. (This is understandable, in that only four practical chemistry sessions had been held in that particular semester, which is hardly a quantity likely to be of much use.

5.3.1.2 MEET WITH CURRENT BRIDGING COURSE STUDENTS AND RECORD OBSERVATIONS DURING A PRACTICAL SESSION

5.3.1.2.1 Observations:

The duration of the pre-prac talk

BT: Approximately 15 minutes but none on the day of the interview as that day's practical work was a revision session.

TWR: Approximately 15 minutes, as on this visit as it was a new practical session. It was disappointingly not well constructed. Other instructions were delivered during the session.

When and where demos are done for each practical

BT: On the front bench so all students could see the lecturer and be involved in the demonstration.

TWR: On the front bench where the lecturer was clearly visible to the class.

Whether students participate in the pre-prac talk

BT: YES — on a question and answer basis which was led by the lecturer.

TWR: NO — very little interaction. The students read through the instructions and began working. Questions arose only during the practical.

Whether students are prepared for the practical they are about to participate in

BT: YES — the practical was set up and prepared for by the students, using previous theory lecture notes and understanding.

TWR: No — the students received the practical sheets/handouts on the day.

Whether students work individually or in larger groups and if so why?

BT: Two per group

TWR: The students worked individually as there were only twenty in the group. This group was specifically constituted for the Analytical Chemistry Diploma course.

Whether the laboratories are technique-centred rather than lecture orientated

BT: Technique-centred, which emphasises the need to develop hands-on experience since that is the area students have been disadvantaged in.

TWR: Technique-centred, to ensure that students from disadvantaged backgrounds receive hands-on experience with laboratory equipment.

Whether students are comfortable with the glassware usage

BT: the students appeared to be very comfortable with the glassware and other hardware they were making use of. Training throughout the course had ensured that they were able to use the laboratory equipment with relative ease and minimal assistance, ensuring they would cope better in the formal course, after such experience.

TWR: for these particular students it was their first time of involvement with the particular glassware so they needed much assistance. That again emphasises the need for extensive training for these students before they reach the formal courses, where they are expected to recognise the laboratory equipment and handle it correctly, with minimal assistance.

Whether they appear to be interested in the particular prac

BT: The students appeared to be very interested in the practical session.

TWR: These students were interested in the session but because of the instructions being delivered during the session they were unable to concentrate clearly on each task at hand.

Note the attitude to the practical work?

BT: The students exhibited positive attitudes to the practical work. Examinations were imminent, so practical work had become even more important.

TWR: These students were positive about practical work and the lecturers stated that students attended practical sessions even though they do not have to pass the practical to complete the course.

Whether locker/glassware is available for student use

BT: The students were supplied with locker kits which were more than adequate for practicals.

TWR: Each student had a laboratory locker which was adequately stocked for practicals.

Whether the laboratory space is adequate

BT: The laboratory was large, clean and in good condition with adequate space but perhaps suitable ventilation needed to be addressed.

TWR: The laboratory was large, clean, in good condition and well ventilated.

Whether students take practical work seriously and why?

BT: The students took the practical work seriously. Marks obtained from practical work play a significant part in their final marks, which ensures they realise the importance of such tuition.

TWR: The students realised the practical had been specifically designed to assist their learning needs and reinforce theory .

Whether the lab period is divided into a skill learning period (in which skills are explicitly taught) followed by a period in which students will use their skills in a prescribed situation thus gaining experience of skills taught?

BT: According to the lecturer that was so. Obviously, for the observed recapitulation session this was not the case. The skills had already been taught but were being refined.

TWR: This was so. In the observed session the students learnt how to titrate and were then asked to use those skills in completing a practical exercise.

5.3.1.2.2 Student Profile:

Group A (in practical class)

No of students present: 12

Previous practical experience:

No practicals at school	**Very few practicals and almost no hands-on experience**	**Some practical experience but mainly teacher demonstration**	**Did have practicals**	**Total**
8	1	2	1	12

Group B (who were attending lectures during the corresponding time period)

No of students present: 17

Previous practical experience:

No practicals at school	**Very few practicals and almost no hands-on experience**	**Some practical experience but mainly teacher demonstration**	**Did have practicals**	**Total**
5	3	9	nil	17

MATRIC GRADES

Physical Science:

HG	SG
C:1 D:0 E:3 F:3 G:2	C:0 D:0 E:3 F:4 G:0 H:1
Total:9	**Total:8**

Mathematics

HG	SG
	D:2 E:5 F:10
	Total: 17

Of the seventeen students, only three are still achieving only an E for these two subjects, in the Tertiary Foundation Course, whereas the balance of the students are obtaining D and higher.

The writer also questioned the student who had obtained a C in HG for Physical Science about the worth of the course to her. She praised the course and stated that the practicals linked to theory were of substantial benefit to her.

5.3.1.2.3 QUESTIONS FOR STUDENTS TO ANSWER:

Are students prepared for the practical they are about to participate in?

BT: Yes and it would appear that they were given a schedule and manuals, and were ready for each session.

TWR: No — they did not receive their practical handouts before the session.

Are students given learning objectives for the practical?

BT: They were given general objectives from which they had to extract a particular aim for the practical in question.

TWR: The objective was supplied in the form of an aim for the practical.

How many hours do students spend on preparing (if any)?

BT: This is varied but the students answered that they generally spent between 15 and 30 minutes preparing.

TWR: No preparation work had been done.

Is a pre-prac talk beneficial?

If YES, why?/If NO, why?

BT: The students felt that it was beneficial as it ensured their focus was correct.

TWR: Yes, as it was beneficial in assisting with the objective of the practical.

What could the student recognise in terms of glassware and other laboratory facilities when beginning the course?

BT: The majority of students stated that they recognised very little.

TWR: The students had very little laboratory experience and recognised very little laboratory equipment when they started the course.

What could the student do in a laboratory when first attending?

BT: Most of the students agreed that they could do very little.

TWR: Most students agreed that their practical experience had been so limited that they could do very little in terms of laboratory work when they started the course.

Do students prefer working as currently arranged (i.e. individually or larger groupings whichever is the case), or not?

Which arrangement is preferable and why?

BT: Some students enjoyed working in pairs while others would have liked to work individually, but they were not strongly committed either way.

TWR: These students were pleased to have their own lockers and to be able to work individually because it was different from the overcrowded conditions they had been used to at secondary school.

Do students regard practicals as an integral part of their chemistry and/or physics course?

BT: The students were emphatic in their positive response.

TWR: Yes.

Are the practicals linked to their theory (their perceptions)?

BT: Yes, directly — especially in the way in which preparations for the practicals were integrated with lecture periods.

TWR: The perceptions were that only sometimes was this true.

How many hours do students spend on report writing/presentation of data (whichever is required)?

BT: This was mainly done during the practical session.

TWR: None.

Would students like a feedback session regarding mistakes, reports and marking? (And why?)

BT: This was not necessary because of continual interaction during the practical.

TWR: Discussions were held during the practical so this was not an issue.

Which is preferable for reporting — sheets for data presentation or completion of a full report write-up?

BT: The students did not need to know the full requirements of a report, because a data fill-in report form was preferable.

TWR: Not applicable

Are students looking forward to the formal course and in particular practical work?

BT: The students were unanimous that they were looking forward to the formal course and the practical work.

TWR: All students agreed that they were indeed looking forward to attending the formal course.

Would students like to visit industry to see practical work in real life?

BT: The students were unanimous in this wish.

TWR: All students agreed that this would be most welcome.

Has the course been beneficial to them, and why?

BT: Yes, as it had helped to build up their confidence in the learning of science, and invaluable experience in practical work was obtained.

TWR: The students felt the course had been beneficial as the link between theory and practical had been emphasised and practical experience had enabled them to gain confidence in that area.

What (if any) changes would they like to see concerning the bridging course and in particular the practical work (eg. recognition of the course):

BT: These students were more than happy with the course and were satisfied because it was given recognition. The students questioned (who were in a lecture and not in a practical session) made some suggestions: Mathematics should include more problem-solving work. Communication needed to be more creative, and some felt the emphasis on Analytical Chemistry should be lessened but that perhaps different bridging courses specific to a discipline would be advantageous.

TWR: The students were satisfied with the course.

Would students like to evaluate the practical course when the semester ends?

BT: The students were somewhat non-committal on this but agreed it would be a good idea.

TWR: This question not given to these students.

5.3.1.2.4 Thank all the personnel involved with making the visit possible and thank the staff and students for their valuable input.

5.3.1.3 INTERVIEWS WITH PREVIOUS STUDENTS FROM TFC and A MEMBER OF THE LABORATORY STAFF

This section is applicable only to Border Technikon as the writer was unable to interview anyone else at TWR in full.

5.3.1.3.1 The writer interviewed four past Tertiary Foundation Course (TFC) students now in the formal S1 Analytical Chemistry class:

All were positive about the benefits of attending the TFC course. They highlighted the practical experience gained and claimed also that the course provided a good introduction to campus life. The students declared that they had no problems during practicals in S1 as they were much more confident in the use of laboratory equipment as well as in taking part in practicals.

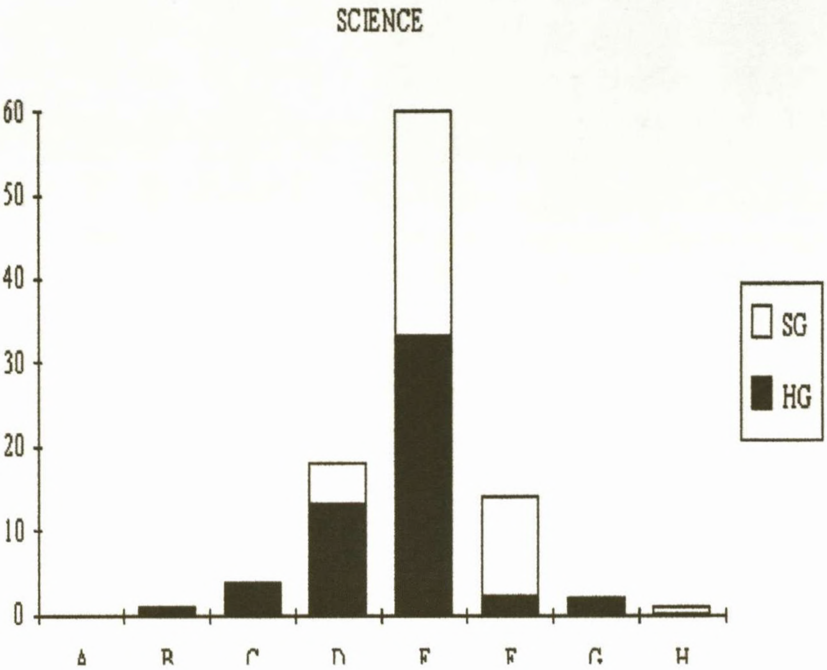
5.3.1.3.2 The writer also interviewed a current S5 student who is doing in-service training on the campus. He attended Thubulethu High School in Fort Beaufort where he was fortunate to have Science classes which involved much practical work and where students worked individually, although the more difficult practicals were run as teacher demonstrations. His Matric grade for Mathematics was D (HG) and for Physical Science E (SG). He had attended the TFC course, which he spoke highly of, and had enjoyed the practical work. He had been promoted after each semester. It would appear that his solid grounding in Physical Science at school and again in the TFC course has been most advantageous.

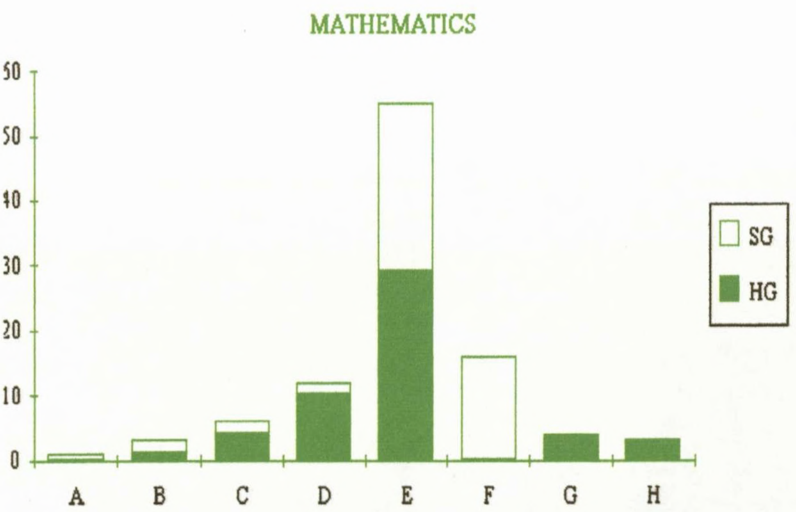
5.3.1.3.3 The writer interviewed the Chemical Technician who was in charge of preparing the practical sessions in the Analytical Chemistry Department. He reported that in a meeting two weeks previously the staff had noted that TFC students in the formal level S1 were coping better than those students directly from school. In his experience, he said, it was evident that TFC students coped better with practical work in the formal course than those who had not done the course.

Appendix 11

Mathematics and Physical Science Matriculation Results (1989/1990)

(Total students: 100)

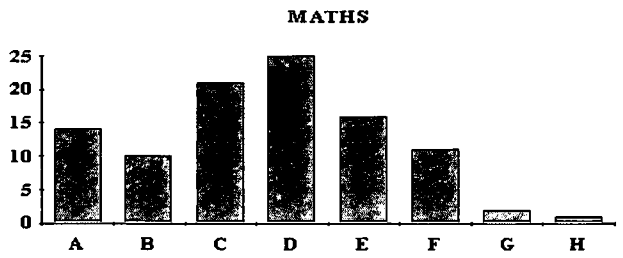


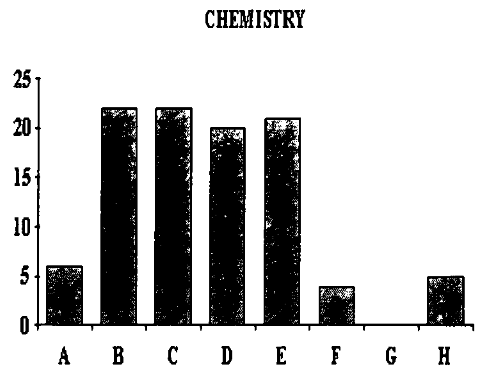


GRAPH OF MATRICULATION SYMBOLS FOR MATHEMATICS
(TOTAL STUDENTS 100)

Appendix 12

Mathematics and Chemistry Results for Pre-Technician students (1989/1990)





(Lafferty and O'Brien, 1994)

REFERENCES

Advisory Council for Universities and Technikons, 1992. "Academic Support and Bridging Programmes at Universities and Technikons in South Africa" NATED 02-318 (92/11)

Aggarwal, JC 1992. "Philosophical and Sociological Bases of Education", 8th Edition, Vikas Publishing House, New Delhi.

Association of Canadian Community Colleges/Canadian International Development Agency, 1995. "Reaching Out (COTIL)", Mangosuthu Technikon, Creda Press.

Badenhorst, DC, 1984. "Ground motives in the education system of South Africa", O.J. van Schalkwyk, E.I. Dekker, J.S.Goodey, S.G.Pretorius and E.M. Lemmer (Eds), Pretoria.

Barber, S, 1996. South Africa is bottom of the class. The Sunday Times. 23 June, 1-2.

Barron, C, 1996. Academics too tired and poor to keep up. The Sunday Times. 23 June, 7.

Beasley WF and Chant D, 1996. "Student perspectives on their skill development during a small scale laboratory course", Australian Journal of Chemistry, No. 41.

Ben-Zvi R, Hofstein A and Samuel D 1977. "Modes of Instruction in High School Chemistry", Journal of Research in Science Teaching", Vol. 14 No. 5.

Blair et al, 1956. "Educational Psychology", MacMillan, New York.

Boud D, Dunn J and Hegarty-Hazel 1986. "Teaching in Laboratories", SRHE & NFER-NELSON, Guildford, Surrey.

Bradley JC, 1997. "From the Cape to Cairo: Microchemistry is changing the face of school chemistry", Chemical Processing, March.

Bradley J, Staskun MG and White MD 1991. "The anatomy of a problem Chemistry II course", SAJE/SATHO Vol. 5 No.2.

Brattan Dr. D, 1994. "Winds of change", Education in Chemistry, January.

Brightman Dr. CAJ, 1992. "Being practical", Education in Chemistry, September.

Bryce TGK, McCall J, MacGregor et al, 1983. "Techniques for the Assessment of Practical Skills in Foundation Science (TAPS)", Heinemann, London.

Bryce TGK, McCall J, MacGregor et al, 1987. "TAPS: Report of the Project Phase 2 1983 - 1986", Jordan Hill College of Education, Edinburgh.

Carnduff John, 1992. "Degree courses - the way forward?", Education in Chemistry, July.

CASME Annual Report, 1994. A Shell South Africa Project. Printed at University of Natal for CASME (A Shell South Africa Project).

CASME and Link-Africa, 1995. A Report on School Science Project. Printed at University of Natal for CASME (A Shell South Africa Project).

Child D, 1993. "Psychology and the Teacher" Holt, Rinehart & Winston, London.

Christofi C & Davies M, 1992. "Good Chemistry", International Newsletter on Chemical Education, June, No.37.

Cole MJA, 1975. "Science Teaching and Science Curriculum Development in a Supposedly Non-Scientific Culture", West African Journal of Education, Vol. 19.

Cooper MM, 1995. "Cooperative Learning: An Approach for large Enrollment Courses", Journal of Chemical Education, Vol. 72, No. 2.

Crisp J, 1990. "Academic Support Programmes & Bridging Courses at Tertiary Level....Closure". Proceedings of an HSRC seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering.

Davidson N, 1990. "Cooperative learning in Mathematics", Addison-Wesley, California.

De Meo Stephen, 1995. "The role of the affective domain in learning chemistry", Journal of Chemical Education, Vol. 72.

Department of National Education, 1994. "Requirements for National Instructional Programmes at Technikons", The National Education Policy, NATED 02-150 (94/01).

Department of Arts, Culture, Science and Technology, 1996. "South Africa's Green Paper on Science and Technology: Preparing for the 21st Century", CTP Book Printers, Parow, Cape Town.

Devenport, Lazonby and Waddington, 1979. "Attitudes to Practicals", Education in Chemistry, November.

Driver R et al, 1994. "Constructing Scientific Knowledge in the Classroom", Educational Researcher, October.

Editor The, 1992. "Bridging the secondary-tertiary divide...", Education in Chemistry, July.

Editor The, 1993. "Take-off with chemistry", Education in Chemistry, July.

Editor The, 1994. "More practical conclusions", Education in Chemistry, September.

Education and Training White Paper Committee, 1994. "Draft Policy Document: Education and Training in a Democratic South Africa", RSA Ministry of Education, Johannesburg.

Education and Training, National Commission on Higher Education, 1995. "Reason for the Commission.....", Paper circulated by SAAAD requesting submissions to the NCHE, Pretoria.

Edusource: EDUSOURCE DATA NEWS, No 4; Education Foundation of South Africa, Johannesburg, December 1993.

Fester V, Gihwala D and Sadeck M 1990. "A Workable Model for a Bridging Course in Science", Unpublished Paper read at a SAAAD Conference in 1990.

Fish DB and Crossland JR, 1995. "Using Local Industries to Make Science Real", Paper prepared for Science-in-Industry Teacher Programme - SIITP.

Fransman, HJ, 1991. "Students' preferences for learning from an evaluation point of view". South African Journal of Higher Education. Vol 5, No 2.

Gardner and Gauld, 1990. "Scientific Attitudes", Studies in Science Education.

Garnett P and O'Loughlin M, 1989. "Using Practical tests to assess laboratory work in Chemistry", The Australian Science Teachers Journal, Vol. 35 No. 4.

Gerrans, GC, 1996. "Chemical Education - South African initiatives". Chemical Processing SA. Jan/Feb.

Gerrans GC, Huddle PA and van Zyl P, 1991. "The impact of new teaching and learning strategies in a pre-university chemistry course", SAJHE/SATHO, Vol. 5 No. 2.

Giddings G and Hofstein A, 1980. "Trends in the Assessment of Laboratory Performance in High School Science Instruction", The Australian Science Teachers Journal, Vol. 26 No. 3.

Goedhart, MJ, 1996. "A gap between theory and practice; a major problem in University chemistry teaching". Proceedings of Variety in Chemistry Teaching 1996. Produced for University of York, England.

Goodier C, 1995. "The Language Component of the Pre-technician Course, Port Elizabeth Technikon", Paper presented to the Regional Language Interest, SAAAD, Port Elizabeth.

Gott R and Duggan S, 1995. "Investigative work in the science curriculum", Open University Press, Buckingham.

Grayson, D, 1992. "The Science Foundation programme a holistic approach". The Second HSRC Seminar on Academic Support Programmes and Bridging Courses in Tertiary Education for Mathematics, Science and Engineering. HSRC, Pretoria.

Hawkins, G, 1988. The Oxford Dictionary, Oxford University Press, Oxford.

Hegarty-Hazel E, 1990. "The Student Laboratory and the Science Curriculum", Routledge, London.

Hillman J, 1990. "A Personal Development Curriculum For Educationally disadvantaged Engineering Students", Paper presented at HSRC Seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering, Potchefstroom University.

Hills Prof G, 1992. "'................will it ever work in theory?'", Education in Chemistry, Vol. 29, No. 1.

Hofstein A, Ben-Zvi R and Samuel D, 1976. "The Measurement of the Interest in, and Attitudes to, laboratory Work amongst Israeli High School Chemistry Students", Science Education, Vol. 60.

Howard A, 1986. Journal of Applied Psychology.

HSRC 1990. "1st Seminar on Bridging Programmes" HSRC Seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering, Potchefstroom University.

HSRC 1992. "2nd Seminar on Bridging programmes", .HSRC Seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering, Potchefstroom University.

HSRC, 1995. "Special communique No. 10", One of a series of news letters published by the HSRC.

Huddle PA and Bradley JA, 1991. "The impact of a pre-university school course in chemistry on Chemistry I achievement", SAJHE/SATHO, Vol. 5 No. 1.

Hunter P, 1989. "The transforming of learning:the evolution of an academic support programme", SAJHE/SATHO, Vol. 3, No. 2.

Hunter P, 1990. "Bridging, Support and the Institutional Mainstream: Models and Issues", Paper presented at the HSRC Seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering.

Isaac S and Michael WB, 1990. "Handbook in Research and Evaluation" 2nd Edition, EdiTS publishers, San Diego.

James CB, 1989. "Cooperative learning in the classroom", The Social Studies, May/June.

Jawitz J, 1993. "Academic problems facing Engineering Support Programmes", Paper presented at HSRC Seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering, Potchefstroom University.

Jiya Z, 1993. "Language difficulties of black B Sc students", SAJHE/SATHO, Vol. 7, No. 1.

Johnson Jean, 1992. "The Bedford Guide to the research process", 2nd Edition, Bedford Books of St Martin's Press, Boston.

Johnston SH and Wham AJB, 1979. "A model for undergraduate practical work", Education in Chemistry, January.

Johnston SH and Wham AJB, 1982. "The Demands of Practical Work", Education in Chemistry, Vol. 19.

Johnstone AH, Sleet RJ and Vianna JF, 1994. "An Information Processing Model of Learning: its application to an undergraduate laboratory course in chemistry", Studies in Higher Education, Vol. 19 No. 1.

Jorgensen NA, 1995. "What Industry needs from mathematics and science graduates", Paper presented by a representative of the Pretoria Portland Cement Company.

Kahn M, 1993. "Building the base", Report on a Sector Study of Science and mathematics Education for the Commission of the European Communities, Pretoria.

Kahn MichaelJ, 1994. "Science and Technology Education and Training for Economic Development", Working Paper No. 1 produced for the Centre for Education Policy Development, Johannesburg.

Karplus R, 1977. "Science Teaching and The Development of Reasoning", Journal of Research In Science Teaching, Vol. 14, No. 2.

Kirchner PA, 1992. "Practicals in Higher Science Education" Lemma, Utrecht.

Kotecha P and Rutherford M, 1991. "A case for team-teaching language and communication in science and engineering", SAJHE/SATHO, Vol. 5 No. 2.

Kuh G, 1995. "Out-of-class Experiences", Journal of Higher Education, Vol. 66, No. 2.

Lafferty JT, 1995. COTIL Report 1995. Mangosuthu Technikon, Umlazi.

Lawton G, 1997. "Business Skills for Boffins", Chemistry & Industry, October, No. 19.

Leedy Paul, 1980. "Practical Research", 3rd Edition, MacMillan Publishing Company, New York.

Levy Sharon, 1994. " Projects Speak for themselves", Houghton.

Lindeque GF, 1993. "The role of the technikon in a future South Africa", Intertec, 1(1).

Lovell J, 1992. "How can management skills best be taught to chemists?" Education in Chemistry, March.

Lubben F and Millar R, 1995. "Children's ideas about the reliability of experimental data", University of York Science Education Group, York.

Meester MAM and Maskill R, 1993. "The practical side of chemistry", University of East Anglia, Norwich.

Mellville S, 1994. "The ML Sultan Commerce PreTech: bridging the gap?", ML Sultan Technikon Research Bulletin.

Millar R and Driver R, 1987. "Beyond Processes", Studies in Science Education, 14.

Millar R and Lubben F, 1995. "Knowledge and Action: Students' understanding of the procedures of scientific enquiry", Paper presented at the European Conference on research in Science Education, Leeds.

Millar R, Lubben F, Gott R and Duggan S 1994. "Investigating in the school science laboratory:conceptual and procedural knowledge and their influence on performance" Research Papers in Education, Vol. 9 No. 2.

Millar R, 1987. "Towards a role for Experiment in the Science Teaching Laboratory", Studies in Science Education, Vol. 14.

Mitchell IJ and de Jong E, 1994. "Bridging Course in Chemistry and Physics for Engineering Students", Higher Education Research and Development, Vol. 13, No. 2.

Monaghan J, 1992. "The good news from Industry", Education in Britain, Vol. 29.

Moore Dr Glyn, 1996. "Chemical education - no quick fixes", Chemical Processing SA, January/February.

Moreira MA, 1980. "A Non-traditional Approach to the Evaluation of laboratory Instruction in General Physics Courses", European Journal of Science Education, Vol.2.

Mouton, Johann, 1996. Understanding social research, JL van Schaik Publishers, Pretoria.

Ottewill GA and Walsh FC, 1997. "Consultancy in the Classroom", Chamistry & Industry, October.

Pella MO, 1961. "The Laboratory and Science Teaching", The Science Teacher, Vol. 28.

Pickering M, 1980. "Are lab courses a waste of time", The Chronicle of Higher Education, Vol. 19.

Piek GC and Mahlangu DMD, 1990. "Educational Perspectives and Teaching Practice" De Jager-HAUM Publishers, Pretoria.

Research Institute for Education Planning (Strauss, Plekker and Strauss), 1996. "Education and Manpower Development", University of Orange Free State, Vol. 17.

Research Institute for Education Planning (Strauss, Plekker and Strauss) 1995. "Education and Manpower Development", University of Orange Free State, Vol. 16.

Research Institute for Education Planning (Strauss, Plekker and Strauss) 1994. "Education and Manpower Development", University of Orange Free State, Vol. 15.

Research Institute for Education Planning (Strauss, Plekker and Strauss) 1993. "Education and Manpower Development", University of Orange Free State, Vol. 14.

Richman LouisR, 1994. "The New Worker Elite", Fortune, August 22.

Richmond PE 1979. "Who needs laboratories", Physics Education, Vol. 14.

Rolnick M and Perold H, 1995. "An Approach to Developing a Flexible Core Curriculum for

Science and Technology Compulsory General Education" Prepared for the Centre for Education Policy Development, MacMillan, South Africa.

Scientech, 1995. Life-Long Learning. Prepared for FRD. Pretoria

Scott I, 1994. "The role of academic development programmes in the research and development of higher education", Proceedings of SAAAD Regional Policy Forums.

Seeliger, L, 1996. SA research 'unhealthy'. The Mercury. 20 June. 5.

Sharwood D, 1993. "Bridging Programmes at the Port Elizabeth Technikon", Paper presented as a baseline study for the COTIL Programme, Port Elizabeth.

Sharwood D, 1993. "Evaluation of Bridging Programmes", Paper presented at the Annual SAARMSE Conference.

Sharwood D, 1995. "Turning a Disadvantage into an Advantage", Paper presented at a Workshop: Access to Technikon Study, Durban.

Slabbert JA, 1994. "Metalearning and education for all", SAJHE/SATHO, Vol. 8, No. 1.

Solomon J, 1980. "Teaching Children in the Laboratory", Croom Helm Ltd, London.

Solomon J, 1989. "A study of behaviour in the teaching laboratory", International Journal of Science Education, Vol. 11 No. 3.

Solomon J, 1988. "Learning Through Experiment", Studies in Science Education, Vol. 15.

South Africa: Ministry of Education, 1994. "Draft: Education and Training in a Democratic South Africa", Government Printer, Pretoria.

Starfield, S, 1994. "Multicultural Classrooms in Higher Education" English Quarterly, Vol.26, No. 3, (Spring)

Strydom AE, 1994. "Reconstructing tertiary education in a new South Africa: Key issues facing technikons", Paper presented at HSRC Seminar: Academic Support Programmes & Bridging Courses in Tertiary Education - Mathematics, Sciences and Engineering, Potchefstroom University.

Strydom AH, 1993. "Bridging Courses at SA Technikons", University of Orange Free State.

Sutman F and Scmuckler J, 1995. "The laboratory experience", Chemistry & Industry, March.

Tamir Pinchas, 1977. "How are the Laboratories used?", Journal of Research in Teaching, Vol. 14. No.4.

The Royal Society of Chemistry, Tertiary Education Group, 1995. "Variety in Chemistry Teaching Meeting 1995", This Book of Abstracts and Proceedings produced for the meeting at University of York, England.

The Royal Society of Chemistry, Tertiary Education Group, 1996. "Variety in Chemistry Teaching Meeting 1996", This Book of Abstracts and Proceedings produced for the meeting at University of York, England.

Webb Paul and Erwee Jan, 1988. "Easing access to tertiary education : intervention programmes for pupils and teachers", SAJHE/SATHO, Vol. 4 No. 1.

Weitzman, D, 1996. "The relevance of Society to chemistry degrees". Proceedings of Variety in Chemistry Teaching 1996. Produced for University of York, England.

Wellington J, 1989. "Skills and Processes in Science Education: a critical analysis", Routledge, London.

White RT, 1988. "Learning Science", Page Bros Ltd. Norwich.

Woolnough B and Toh KA, 1990. "Alternative approaches to assessment of practical work in science", Science Education Notes, SSR, Vol. 71.

Woolnough B, 1991. "Practical Science", Milton Keynes: Open University Press, England.

Woolnough, B, 1994. Effective Science Teaching, Open University Press, Buckingham, England.