THE MATHEMATICS ACHIEVEMENT OF SYSTEM STUDENT TEACHERS IN THE NORTHERN CAPE WITH SPECIAL REFERENCE TO STUDY ORIENTATION IN MATHEMATICS AND MENTORSHIP

by

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OPSOMMING

Die wiskundeprestasie van SYSTEM-onderwysstudente in die Noord-Kaap met spesifieke verwysing na studie-oriëntering in wiskunde en mentorskap

Gegewe die historiese swak prestasie van leerders in wiskunde en wetenskap, asook die groot aantal onder- en ongekwalifiseerde wiskunde- en wetenskaponderwysers, het die nuut-verkose post-1994-regering, in konsultasie met veelvuldige belanghebbendes, `n projek van opvoedkundige regstelling inhierdie verband geïnisieer, naamlik "Students and Youth into Science, Technology, Engineering and Mathematics" projek of kortweg SYSTEM.

Die visie van SYSTEM was om by te dra tot die regstelling van die historiese wanbelans in die onderwys- en opleidingstelsel in Suid-Afrika. Die projek het `n geleentheid gebied waardeur histories minderbevoorregte leerders in wiskunde- en wetenskapprogramme (soos die "Recovery"-program van SYSTEM Fase I) toegang kon kry tot programme by hoër-onderwysinrigtings (soos die onderwyseropleidingsprogram van SYSTEM Fase II). Die sukses van SYSTEM het primêr op die werkverrigting en prestasie van die studente in die SYSTEM-programme berus. Binne hierdie kontekstuele raamwerk maak die studie spesifieke verwysing na studie-oriëntering in wiskunde, insluitend wiskunde-angs en houding jeens wiskunde, as moontlike oorsaaklike faktore wat werkverrigting en prestasie in wiskunde kan belemmer of versterk. `n Internskap gekoppel aan `n mentorskapprogram is binne die onderwyseropleidingsprogram gestruktureer en ondersoek; onderhoude is met mentor-onderwysers en `n groep SYSTEM-studente gevoer om hul persepsies teenoor aspekte van die mentorproses te bepaal. In die SYSTEM-studentepopulasie (in die Noord-Kaap) is twee disjunkte groepe onderskei wat met verskillende intreevlakke tot Fase II toegetree het. Die verband tussen groeppersepsies en die onderskeie studieveranderlikes is ondersoek binne die konstrukte van leer (instituut-gebaseer) en onderrig (skool-gebaseer). Beide kwantitatiewe en kwalitatiewe ontleding en verslaggewing van die resultate is in die ondersoek gebruik.

Die resultate het aangedui dat die verskil tussen die persepsies van die twee groepe proefpersone nie prakties betekenisvol was nie. Fase I het dus geen beduidende of wesenlike rol in die voorbereiding van die betrokke groep studente vir onderwyseropleiding gehad nie.

Die relevansie van mentorskap vir SYSTEM is ondersoek deur die respondente (SYSTEM-studente en mentoronderwysers) se persepsies rakende die mentorproses te bepaal. Die onderhoude wat gevoer is, getuig van `n erkenning van die relatiewe sukses van SYSTEM in die Noord-Kaap, nieteenstaande die funksionele en strukturele probleme wat op nasionale sowel as provinsiale vlak met die projek geassosieer is.

Om die momentum van transformasie van die onderwys- en opleidingstelsel te behou, behoort die lesse wat in SYSTEM geleer is as `n vertrekpunt vir die voorgestelde regstelling en transformasie van die Verdere Ondewys- en Opleidingband en die Hoër Onderwyssektor oorweeg te word. Meer spesifiek, behoort opvoedkundige transformasie nie bloot kognitief gekontekstualiseer aangepak te word nie, aangesien hierdie studie indirek toon dat die affektiewe terrein meer prominente aandag in kurrikulumontwikkeling, onderwysopleiding en navorsing oor onderrig en leer behoort te kry. Deur op hierdie inisiatiewe voort te bou, kan die huidige staat van leerders en studente se werkverrigting en prestasie in wiskunde verbeter. `n Verdere moontlike bydrae van sodanige programme kan `n vermeerdering in die getal toepaslik gekwalifiseerde wiskunde- en wetenskaponderwysers wees.

Woorde vir indeksering:

Wiskunde; leer; onderrig; prestasie; studie-oriëntering; angs; houding; onderwyseropleiding; onderwys/opvoedkundige regstelling; onderwys/opvoedkundige transformasie; internskap; mentorskap; SYSTEM.

SUMMARY

Given the historically poor performances in mathematics and science by learners, as well as the large number of under- and unqualified mathematics and science teachers, the newly elected post-1994 government, in consultation with numerous stakeholders, initiated a project of educational redress. The project: Students and Youth into Science, Technology, Engineering and Mathematics, was given the acronym SYSTEM.

The vision of SYSTEM was to address the historical imbalances within the education and training system in South Africa. The project provided a vehicle whereby historically disadvantaged mathematics and science learners could access programmes (like the Recovery programme of SYSTEM Phase I) so as to gain entry into programmes at institutions of higher education (like the teacher-training programme of SYSTEM Phase II). The success of SYSTEM ultimately resided in the performances and achievements of the students in the SYSTEM programmes. Within this contextual framework the study made special reference to Study orientation in mathematics, including Mathematics anxiety and Attitude towards mathematics, as possible causative factors that could inhibit/enhance performance and achievement in mathematics. An internship period linked to a mentorship programme was structured within the teacher-training programme, and interviews were conducted with the mentor teachers and a selected group of SYSTEM students so as to elicit their perceptions towards aspects of the mentoring process. The SYSTEM students' study population (from the Northern Cape) was differentiated into dichotomous groups, each group having different entry levels into Phase II. Examinations of group perceptions towards the study variables were done within the constructs of learning (institute-based) and teaching (field-based). Both qualitative and quantitative analyses and reporting of the results were done.

The results showed that the differences between the perceptions of the two sampled groups were not of practical significance. Phase I had no influential role in preparing its group of students for teacher-training.

The relevance of mentorship to SYSTEM was measured by the perceptions of the respondents (SYSTEM students and mentor teachers). The interviews attested to an acknowledgement of the relative success of SYSTEM in the Northern Cape, notwithstanding the functional and structural problems associated with the project both at national and provincial levels.

To sustain the momentum of transformation of our education and training system, lessons learnt from SYSTEM should serve as a benchmark for the envisaged reform and transformation of the FET and Higher Education sectors. In particular, educational transformation should not only be cognitively contextual, since this study has indirectly shown that the affective domain should receive more attention in curriculum development, teacher education and research on teaching and learning. By embarking on these initiatives, the current state of learners and students' performances and achievements in mathematics and science may be ameliorated. A further spin-off could possibly be an increase in the number of suitably qualified mathematics and science teachers.

Words for indexing:

Mathematics; learning; teaching; achievement; study orientation; anxiety; attitude; teacher education; educational redress; educational transformation; internship; mentorship; SYSTEM.

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ABBREVIATIONS AND ACRONYMS

AAT	Achievement Anxiety Test
ABET	Adult Basic Education and Training
ANC	African National Congress
CEPD	Centre for Education Policy Development
CHED	Committee of Heads of Education Departments
COTEP	Committee on Teacher Education Policy
CPED	Cassell's Pocket English Dictionary
CUP	Committee of University Principals
DoE	National Department of Education
ES	Effect Size
FDE	Further Diploma in Education (currently ACE-Advanced Certificate in Education)
FET	Further Education and Training
FIMS	First International Mathematics Study
GET	General Education and Training
GNU	Government of National Unity
HEDCOM	Heads of Education Committee
HG	Higher Grade
HSRC	Human Sciences Research Council
IEA	International Association for Educational Achievement
IEB	Independent Examination Board
INSET	In-service Education and Training
LACs	Learning Areas Committees
LSEN	Learners with Special Education Needs

MA-MARS	Modified and Adapted Mathematics Anxiety Rating Scale
MARS	Mathematics Anxiety Rating Scale
MAS	Mathematics Anxiety Scale
MA-SOM-T	Modified and Adapted Study Orientation in Mathematics-Tertiary
MLMMS	Mathematical Literacy, Mathematics and Mathematical Sciences
NCS	National Curriculum Statement
NECC	National Education Co-ordinating Committee
NEPI	National Education Policy Investigation
NGO	Non-Governmental Organisation
NQF	National Qualifications Framework
OBE	Outcomes-Based Education
PRESET	Pre-service Education and Training
SA	South Africa
SACE	South African Council for Educators
SADTU	South African Democratic Teachers Union
SAFCERT	South African Certification Council
SAQA	South African Qualifications Authority
SG	Standard Grade
SIMS	Second International Mathematics Study
SOs	Specific Outcomes
SOM	Study Orientation in Mathematics
SOMT	Study Orientation in Mathematics-Tertiary
SQ	Student Questionnaire
STAI	State-Trait Anxiety Inventory

STEC	Science and Technology Education Commission
SYSTEM	Students and Youth into Science, Technology, Engineering and Mathematics
TAI	Test Anxiety Inventory
TAQ	Test Anxiety Questionnaire
TIMSS	Third International Mathematics and Science Study
TIMSS-R	Third International Mathematics and Science Study-Repeat

CHAPTER 1

INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 STATEMENT OF THE PROBLEM

Transformation of education and training in post-1994 South Africa has become focused on the shift away from the traditional aims-objectives approach to Outcomes-Based Education (OBE) and Curriculum 2005 (National Department of Education [*1], 1997: 1). Educationalists describe these changes as a systemic shift away from what has been labelled the "instruction paradigm" to the "learning paradigm" (Barr & Tagg, 1995: 13).

According to Kahn and Volmink (2000: 3), the Curriculum 2005 process is two-fold with reference to mathematics and science education:

- To redress historical imbalances.
- To deconstruct the uninviting image of mathematics and science.

Prior to 1994, much of the educational innovations in mathematics and science education which occurred were located in Non-Governmental Organisations (NGOs) supported by the private sector. Given the historically poor performance in mathematics and science by learners, as well as the large number of under-qualified mathematics and science teachers (Kahn & Rollnick, 1993: 261), the new Ministry of Education, in consultation with numerous stakeholders, initiated a project of educational redress. This project: Students and Youth into Science, Technology, Engineering and Mathematics, was given the acronym *SYSTEM.*

[*1] Herewith referred to as the Department of Education or DoE.

The notion of a student recovery (second chance) programme (Phase I), linked to a teacher-training programme (Phase II) emerged from this project. In view of the DoE's educational reform efforts, SYSTEM became embedded within a socio-constructivistic environment (see Table 3.1).

The success of SYSTEM ultimately resided in the performances and achievements of the students in the SYSTEM programmes (Phase I & Phase II). By examining the perceptions of these students (in Phase II), particularly towards the learning and teaching of mathematics, a better understanding could be obtained of the factors contributing to poor results. Within this contextual framework the study made special reference to *Study orientation in mathematics*, including *Mathematics anxiety* and *Attitude towards mathematics*, as possible causative variables (independent) that could inhibit / enhance performance and achievement. The dependent variable was the *Achievement in mathematics* and was measured from a setting of institutional learning and field practice (internship). The selection of these variables, for use in this study, was based on research undertaken by Maree, Prinsloo and Claasen (1997: 3) which showed that there was a statistically significant association between aspects of Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics in influencing Achievements in mathematics. The design of the empirical component of this study was not to investigate the correlations between these variables but rather use them as determinants to detect any significant differences between group perceptions. However, the inter-relatedness of these variables are acknowledged (see paragraph 3.6) in this study in context of their influential roles on the teaching and learning processes. [See also Figure 3.1, for a schematic representation of the delineation of the fields of measure].

Anxiety is defined as "being distressed about some event" (CPED[*2], 1995: 31). According to Posamentier and Stepelman (1990: 210), mathematics anxiety is defined as a state of discomfort that occurs in response to situations involving mathematical tasks that are perceived as threatening to a learner's self-esteem.

[*2] Cassell's Pocket English Dictionary (CPED).

In turn, these feelings of anxiety can lead to panic, tension, helplessness, fear, distress, shame, inability to cope and loss of ability to concentrate. Bessant (1995: 327) contends that mathematics anxiety is a euphemism for poor performance, low self-confidence, fear of failure, and negative feelings towards mathematics. Studies done by Maree (as quoted in the HSRC Report, 1997) identify, *inter alia*, language problems, other than mother-tongue instruction, to cause mathematics anxiety and undermine achievement in the subject. Bessant (1995: 343) states that inquiries into study orientations can form an important theoretical link in explaining mathematics anxiety. In other contemporary studies, researchers have identified and examined underlying causes and significant relationships dealing with mathematics anxiety (Cramer & Oshima, 1992: 18-35; Karp, 1991: 265-270; Pajares & Kranzler, 1995: 192-203; Yee, 1988: 317-333). Kontogianes (as quoted by Vinson, Haynes & Sloan, 1997: 5), after having examined pre-service student teachers' mathematics anxiety, finds that a self-paced programme linked with some degree of mentoring positively affected the pre-service student teachers' mathematics achievements and attitudes. Blackwell (1989: 9) defines mentoring as a process by which experienced persons instruct, counsel, guide and facilitate the development of persons identified as less experienced. The nature and provisioning of mentoring within SYSTEM is discussed in detail in Chapter 4.

SYSTEM Phase II students (pre-service student teachers: herewith referred to as SYSTEM students[*3]) had to complete internships at project schools under the mentorship of selected mathematics and science teachers. The envisaged training of these mentor teachers was considered as part of their professional development, in order that classroom support could be provided to the SYSTEM students during their internship period. The remediating nature of mentorship towards ameliorating negative responses towards performances and achievements are noted in Chapter 4. According to Srivastava (2002: 3), mentoring supports a constructivist-learning environment. Considering the ethos of SYSTEM, it (the project) was ideally positioned to be the first to pilot a mentorship programme within a teacher-training programme in South Africa.

[*3] Refer to paragraph 1.3.2.2 for the designations of Group 1 and Group 2 from the sampled SYSTEM population. Cf. also Table 2.5 & paragraph 5.2.2.

This study analyses SYSTEM as an educational redress initiative through the investigation of the performances and achievements in mathematics of the SYSTEM students in the Northern Cape. From the preceding argumentation, the focus of the statement of the problem becomes broadly parametrize within the following problem questions:

Research Question 1

How did the transformative processes taking place within the education and training system of South Africa influence the gestation of SYSTEM?

Research Question 2

(a) Are there any significant differences in the perceptions of the two sampled groups from the SYSTEM (Phase II) study population, with regard to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics?

(b) How is the project evaluation of SYSTEM defined in terms of students' perceptions towards their performances and achievements in mathematics?

Research Question 3

How relevant was mentorship to the SYSTEM students during the internship period?

Research Question 4

Within the theoretical premises and the empirical results of this study, what recommendations emanating from the SYSTEM project are proposed?

1.2 AIMS OF THE RESEARCH

The aim of the research was to investigate the achievement in mathematics of the SYSTEM students in the Northern Cape, with special reference to Study orientation in mathematics, including Mathematics anxiety and Attitude towards mathematics, and Mentorship.

The objectives of this study were to:

1. Describe the contextual framework of the SYSTEM project from a historical-educational perspective and within the ambit of educational transformation.

2(a). Explain the relevance of the Recovery programme (SYSTEM: Phase I) as a conduit into the teacher-training programme (SYSTEM: Phase II). The perceptions towards the study variables of two sampled groups, from different entry points, were analysed.

(b). Evaluate the SYSTEM project in terms of the students' perceptions towards their performances and achievements in mathematics.

3. Investigate the relevance of mentorship during the internship period.

4. Propose recommendations based on the findings of this study for either the reintroduction, modification or dissolution of SYSTEM. Such a recommendation should be seen against the background of transforming teacher-training programmes in South Africa.

1.3 RESEARCH METHODOLOGY

1.3.1 Literature review

An intensive and comprehensive review of the relevant literature was done to analyse and discuss the inter-relatedness of the Mathematics achievement with Study orientation, Mathematics anxiety and Attitude. This research was supported by several theoretical and empirical studies undertaken by other researchers in their work on Study orientation, Mathematics anxiety and Attitude, as well as its effects on Achievement in mathematics. A literature study was also undertaken on research done in the field of mentoring and mentorship, by focusing on key aspects relevant to this study.

A DIALOG search was undertaken using the following keywords:
Anxiety, beliefs, attitudes, emotions, mathematics, student anxiety, teacher anxiety, test anxiety, performance anxiety, evaluation anxiety, mathematics learning, mathematics teaching, mentorship, mathematics achievement.

1.3.2 Empirical study

1.3.2.1 *Research design*

This study used field survey-type techniques. A non-experimental survey was used to collect data and later used in exploring the relationships between group responses (cf. also Welman & Kruger, 1999: 84). Measurements were one-off and no longitudinal variations of measures were made.

1.3.2.2 *Population and sample*

The study population (N = 22) for the non-experimental sample consisted of the pre-service students following the SYSTEM Secondary Teachers' Diploma course (Phase II) from The Amalgamated Phatsimang and Perseverance College of Education[*4] in Kimberley, Northern Cape Province.

There was a discernible dichotomous sub-group within Phase II, each with different achievement levels in mathematics and physical science. The first group (n = 10) [designated as Group 1] consisted of learners directly from Standard 10 (Grade 12), who applied for teacher-training, with mathematics and physical science as majors, but with no exposure to a post-matriculation or redress programme. The second group (n = 12) [designated as Group 2] consisted of learners that came from Phase I of SYSTEM (the Recovery programme), which was a post-matriculation course targeting learners who achieved very poor matriculation passes in mathematics and physical science. No random sampling was effected.

Nine mathematics mentor teachers were identified prior to the placements of the SYSTEM students at schools for their internship period.

1.3.2.3 *Instruments*

The instruments used in this study were designed to capture the perceptions of the respondents (SYSTEM students and mathematics mentor teachers) in a two-fold approach – using questionnaires and interviews.

The use of questionnaires

(a) An adapted and modified *Study Orientation in Mathematics Questionnaire for Tertiary level* (MA-SOM-T) was used to measure the perceptions of SYSTEM students towards Study orientation in mathematics (see paragraph 3.2.3.1 & Appendix A).

(b) A 20-item questionnaire adapted and modified from the Mathematics Anxiety Rating Scale (MARS) was used. The MA-MARS (the *Modified and Adapted MARS*) focused on the constructs of:

- The anxiety experienced during institutional learning of mathematics
  Sub-scales: Mathematics test anxiety
  General evaluation anxiety
- The anxiety experienced when teaching mathematics during internship
  Sub-scale: Performance anxiety
  [For further elaboration on the MA-MARS instrument, refer to paragraph 3.3.3.1 & Appendix B.]

(c) A 10-item Likert-type questionnaire focusing on Attitudes towards mathematics was used in order to establish a measure of the SYSTEM students' perceptions towards the learning and teaching of mathematics.
[See paragraph 3.4.3.1 & Appendix C.]

(d) A 10-item open-ended questionnaire relating to the perceptions of the SYSTEM students as to their achievements in the learning of mathematics (institute-based) and the teaching of mathematics (field-based) was used.
[Also see paragraph 3.5.3 & Appendix D.]

[Content validity of the questionnaires using a piloting strategy was discussed in paragraphs 3.2.3.1, 3.3.3.1 & 3.4.3.1]

*4 Herewith referred to as the College of Education.

The use of interviews

(a) A student group-interview was conducted and recorded on audio-tape. This interview focused on:

- Mentorship and the mentoring process.
- The internship period.

[The nature of this interview was of the semi-structured type (see paragraph 4.4.1.3) and an *interview guide* (see Appendix F) was prepared.]

(b) Open-ended interviews were conducted with the mathematics mentor teachers and recorded on audio-tape. These interviews focused on their (teachers') perceptions of their roles as mentor teachers, as well as their comments on student achievements during internship (see paragraph 4.4.2).

[The nature of these interviews were constituted along the following lines:

- structured interviews (see paragraph 4.4.1.1) were conducted at four placement schools - an *interview schedule* was prepared (see Appendix E); and
- unstructured interviews (see paragraph 4.4.1.2) were conducted at five placement schools.]

[To ensure the internal validity of these interviews, the technique of triangulation was used (see paragraph 4.4.1.4).]

1.3.2.4 *Statistical techniques*

In line with the aims of the research, a dual statistical approach was adopted throughout the study. The author drew on the following techniques during the empirical research:

1. The use of quantitative techniques by employing descriptive data analysis which focused on:

(a) The Cronbach's Alpha coefficients.
(b) The Means Procedure per group: item means and standard deviations.
(c) Effect sizes (Cohen's d-values) [Cohen, 1988: 20].
(d) The Frequency Procedure per group: item percentages.

2. The use of a qualitative technique:

(a) The technique of triangulation was used to ensure the internal validity of the interviews.

To compute the means, frequencies and coefficients, the primary Windows-based software programme Statistical Analysis System (SAS[*5]) for Windows Release 6.12 (1996) was used.

[*5] Copyright: SAS Institute, Cary, North Carolina. United States of America

Defining Validity and Reliability

Validity: The extent to which an account accurately represents the social phenomena to which it refers (Hammersley, 1990: 57).

In this study two kinds of validity were utilised:

Content validity: The extent to which a measurement reflects the specific intended domain of the content (Carmines & Zeller, 1991: 20).

Internal validity: The degree to which the findings correctly map the phenomenon in question (Silverman, 2000: 91).

Reliability: The extent to which findings can be replicated, or reproduced, by another inquirer (Silverman, 2000: 91). In this study, Cronbach's alpha coefficients are used as a measure of the internal-consistency reliability.

1.3.3 Research procedure

The following research procedure was embarked upon:

- A literature review was done of government documentation and other related articles aimed specifically at improving performances and achievements in mathematics within the transformative educational processes and against the background of Curriculum 2005 and OBE. Pivotal to this setting were the considerations of the parameters for this study that fell within a didactical framework of teaching and learning mathematics.

- A historical-educational overview of SYSTEM (Phases I and II) was done so as to assess the viability of the project to transform mathematics education at post-matriculation and pre-service teaching levels.

- With the aid of adapted and modified instruments of measurement, descriptive data analysis was used to analyse differentiated perceptions of the two sampled groups towards the constructs of learning and teaching of mathematics, with special reference to Study orientation in mathematics, Mathematics anxiety, Attitude towards mathematics and Achievement in mathematics.

- The nature and role of mentorship were established through a literature review study. Interviews were held with the mentor teachers to elicit their perceptions about their roles as mentors, as well as their comments on student achievement during internship. Interviews were held with a group of SYSTEM students (mentees) to elicit their perceptions about mentoring during the internship period.

- From the analysis of the results of the empirical research, conclusions about the strengths and weaknesses of SYSTEM were made in relation to the performances and achievements of the SYSTEM students.

- Recommendations were made based on the project evaluation of SYSTEM within the constructs of teaching and learning mathematics.

1.4 FIELD OF RESEARCH

The core of this research was embedded in the field of learning and teaching mathematics that considered a number of variables which could affect the performances and achievements in mathematics. The study was confined to the SYSTEM project of the Northern Cape Province.

1.5 THE STRUCTURE OF THE DISSERTATION

In this chapter, the initial setting and layout of the study were presented within a framework that detailed the statement of the problem, the problem questions, the aims and the research design. The constructs of teaching and learning mathematics and the variables (both dependent and independent) were identified.

In Chapter 2, the contextual framework of SYSTEM as a product of transformative initiatives in mathematics and science education was discussed. The chapter focused on Phase I and Phase II operational to the Northern Cape Province.

In Chapter 3, a theoretical analysis of the constructs and variables used in this study was done. The inter-relatedness of the variables was explored. This chapter also alluded to the ameliorating nature of mentorship.

The significance of mentorship and its incorporation into the SYSTEM project were focused upon in Chapter 4. Qualitative analyses of student and mentor teacher interviews were reported in this chapter.

In Chapter 5, the methods and procedure used in measuring the variables were outlined.

The use of descriptive statistics to analyse data and the results of the findings were presented in Chapter 6.

Chapter 7 focused on a summary of the theoretical and empirical findings and proposed recommendations based on the evaluation of the SYSTEM project.

CHAPTER 2

THE SYSTEM PROJECT: A HISTORICAL-EDUCATIONAL OVERVIEW WITHIN THE CONTEXT OF TRANSFORMATION

2.1 INTRODUCTION

The aim of this chapter is to address *Research Question 1* by reporting on the contextual framework of the history of SYSTEM against the background of educational transformation. Within the context of policy transformation, the gestation of SYSTEM was associated with the developments in mathematics and science education. The structural and functional designs of the project are outlined in the exposition. Notwithstanding the difficulties experienced during the implementation process of the project, this chapter concludes by focusing on the need for further developments in mathematics and science education as a necessity to sustain the momentum for transformation.

2.2 CONTEXT OF POLICY TRANSFORMATION

The definition of *context of policy,* according to Taylor, Lingard and Henry (1997: 44), refers to the historical background and pressures that lead to the birth of a specific policy. Such a definition should include previous developments and initiatives upon which these policies are built.

Furthermore, policy formulation is viewed as being anchored in a particular vision of a moral order and is thus overtly political (Taylor *et al.*, 1997: 18-19). In education-specific policy formulation could be viewed as a process that conceptualises education as a moral idea and could be linked to the concerns of social justice. Critical to policy formulation is the close attention that has to be paid to the processes involved in the development of the policy and its implementation.

To understand historically how policy is formulated and lodged in government programmes, one has to fit policy formulation into an overall political vision (Kahn, 1996: 282). The political vision for South Africa is the need to change traditional education practices of the pre-1994 period and make them concurrent with the transformational processes underway in the New South Africa. Such a transformation of the education system has to be based on the principles of equity, non-racism and non-sexism that are appropriate to any democratic society (SA, 2000: 9).

The process of transforming education started with the initiatives of the National Education Policy Investigation (NEPI) that brought together some three hundred researchers who dissected the entire education system. Kahn (1996: 283) posits that the most important contribution of the NEPI process was the formulation of a set of core values. These values have since formed the basis for the new educational dispensation. The political vision of the new education policy now embraces democracy, equity, non-racism and non-sexism within a unitary education system as its core values.

The general elections of the 27 April 1994 in South Africa gave rise to a form of power sharing that was embodied in a Government of National Unity (GNU). Unlike the previous regime, the GNU ensured a much greater level of political compromise especially in the field of developing new policies. In the post-1994 period, the implementation of various policy documents and legislation, in particular the South African Schools Act (No. 84 of 1996) has led to fundamental changes in the education system.

The developments of the new education policies were viewed as agents that could bring about unity and redress. The first major statement on post-apartheid education policy was the White Paper of February 1995, subtitled "Education and Training in a Democratic South Africa: First Steps To Develop a New System". It was a statement of intent by the government (Hartshorne, 1999: 109) and contained specific clauses whereby a considerable range of redress initiatives could be carried out.

To Kahn (1996: 282) these new initiatives in education are powerful allies in the transformation and development of mathematics and science education. There were also a number of other policies that were introduced for transforming the education system in South Africa. Some of these policies were directly related to educators, such as the Norms and Standards for Educators, the Code of Conduct for Educators, the Educator Development Appraisal System, the Terms and Conditions of Employment of Educators and the Regulations for the Redeployment and Rationalisation of Employees. Other policies that were considered transformative in nature included Curriculum 2005 (see also paragraph 2.2.1), the National Qualifications Framework (NQF) [see also paragraph 2.2.2], and the policy on education for Learners with Special Education Needs (LSEN).

The structure of Curriculum 2005 is of such a nature that it can be supported / complemented by other educational acts or initiatives. One such act, the National Education Policy Act of 1996, provided a framework for the new Assessment Policy for Grades R-9 and Adult Basic Education and Training (ABET).

In comparison to these new initiatives, the pre-1994 assessment policy, aptly known as "A Rèsume of Instructional Programmes in Public Schools", encapsulated Report 550 which was viewed as having serious shortcomings as an instrument of assessment (SA, 1998d: 110). Because some of the inefficiencies in the old learning system included high repetition and dropout rates, inappropriate use of tests and examinations, etc., these shortcomings were cited as one of the reasons why a new assessment policy had to be developed.

The new Assessment Policy inevitably became focused on an outcomes-based curriculum. The new policy provided a pedagogical basis for Outcomes-Based Education (OBE). It (the policy) focused on the achievement of clearly defined outcomes, making it possible to credit learners' achievements at every level and at whatever rate the learners may acquire the necessary competencies (SA, 1998d: 110).

The common thread between the new curriculum and OBE are its focus on learner-centredness and promoting the notion of a life-long learning educator.

> *The life-long learning educator is an intrinsically motivated and responsible educator, who, throughout his/her life span, engages in his/her own life-long learning and continues the search for information and learning opportunities, thereby contributing to improved teaching practice and learning programmes for others, and education in general* (SA, 2000: 2).

In OBE the focus shifts away from an instructionalist approach towards the considerations of learner outcomes and the improvement of learner assessment. According to Barr and Tagg (1995: 13), some educationalists describe this transformation as a systemic shift away from an "instruction paradigm" towards the "learning paradigm".

2.2.1 Policy Framework: Curriculum 2005 and Outcomes-Based Education (OBE)

In the Government Gazette, No. 17724, dated 19 January 1997, reference is made to the Department of Education's:

- efforts to develop new learning frameworks and learning programmes compliant with the outcomes-based approach of the NQF; and
- aims to phase in the new learning programmes (learning topics) as from January 1998.

The writing of the learning programmes was based on the specific outcomes, which were developed by the Learning Areas Committees (LACs).

There were ten Specific Outcomes (SOs) for the learning area Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS). The SOs are not grade-specific and educators have to assess learners in each grade against the following outcomes:

SO 1: demonstrating an understanding about ways of working with numbers;
SO 2: manipulating number patterns in different ways;
SO 3: demonstrating an understanding of the historical development of mathematics in various social and cultural contexts;
SO 4: critically analysing how mathematical relationships are used in social, political and economic relations;
SO 5: measuring with competence and confidence in a variety of contexts;
SO 6: using data from various contexts to make informed judgements;
SO 7: describing and representing experiences with shape, space, time and motion, using all available senses;
SO 8: analysing natural forms, cultural products and processes as representations of shape, space and time;
SO 9: using mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes; and
SO 10: using various logical processes to formulate, test and justify conjectures.

These SOs were delineated for each of the phases within the NQF bands, namely ABET, General Education and Training (GET) and Further Education and Training (FET) [see Table 2.1]. A Technical Committee was convened and assisted the DoE with this task of delineation.

Furthermore, the duties of the Technical Committee were described as follows:

"*...to assist the LAC and phase co-ordinating committees*" and included the following tasks:

- the writing of specific learning outcomes;
- the clustering of these outcomes;
- investigating the devised levels of achievement; and
- the development of assessment criteria.

(SA, 1997: 1)

The Technical Committee in turn interpreted its brief to mean:

- to refine the outcomes of the eight learning areas;
- to decide on a model;
- to take the model through to its logical conclusion; and
- to provide examples in the form of outcomes, assessment criteria, and range statements.

(SA, 1997: 2)

The eight Learning Areas adopted by the South African Qualifications Authority (SAQA) were:

- Language, Literacy and Communication
- Human and Social Sciences
- Technology
- Mathematical Literacy, Mathematics and Mathematical Sciences
- Natural Sciences
- Arts and Culture
- Economics and Management Science
- Life Orientation.

The Technical Committee also took full cognisance of the discrepancies in the way the new curriculum was being interpreted. To achieve a uniform approach in the interpretation of the new curriculum, a National Curriculum Statement (NCS) for each Learning Area was proposed. The purpose of the NCS was to provide a framework around which provinces and schools could build their learning programmes.

> *The National Curriculum Statement should be descriptive rather than prescriptive and does not provide a syllabus, and should not be used as such* (SA, 1997: 20).

The work of the Technical Committee was later presented through a discussion document that was referred to the provinces for stakeholder input through the LAC structures. Once the provincial processes were completed, the redrafting and finalising of the document were done.

Within the ambit of being transformative, the NCS together with the learning programmes are seen today as guidelines that allow the educator to become innovative, progressive and creative in designing OBE lesson experiences.

From a historical perspective, OBE was founded on the belief that all learners can learn and attain certain results (learning outcomes) not only in a grade alone but can achieve the outcomes through a range of experiences encountered over several grades (Hassan, 2000: 2). Contemporary OBE curricula encourage learners to become active participants in the pursuit of knowledge. Moreover, in OBE:

- critical thinking, reasoning and reflection are encouraged;
- the learning process is made relevant and is connected to real-life situations; and
- flexible time-frames allow learners to work at their own pace.

Furthermore, Curriculum 2005 also allows for cross-curricula integration with other learning areas, emphasising:

- problem-solving skills
- group or team work
- communicative skills
- global vision and inter-relatedness
- civic awareness and responsibility
- professional growth.

2.2.2 Policy Framework: South African Qualifications Authority (SAQA) and the National Qualifications Framework (NQF)

SAQA came into being through the SAQA Act and had 29 representative members from a variety of educational and training constituencies. The sectors responsible for nominating representatives were identified by this Act. It was incumbent on the Minister of Education, in consultation with the Minister of Labour, to eventually appoint members to serve on SAQA.

The mandate of SAQA was to ensure that learners that were awarded NQF standards and qualifications were able to demonstrate the related learning outcomes in accordance with the criteria and requirements specified in those standards and qualifications.

The SAQA Act of 1995 defines a *standard* as:

> *registered statements of desired education and training outcomes and their associated assessment criteria*

and a *qualification* as:

> *the formal recognition of the achievement of the required number and range of credits at specific levels of the National Qualifications Framework.*
>
> (SAQA, 2000a: 11)

SAQAs functions now became two-fold:

- to oversee the development of the NQF, by formulating and publishing policies and criteria for the registration of bodies responsible for establishing education and training standards or qualifications and for accreditation of bodies responsible for monitoring and auditing achievement in terms of such standards and qualifications; and
- to oversee the implementation of the NQF by ensuring the registration, accreditation and assignment of functions to the bodies referred to above, as well as the registration of national standards and qualifications on the framework.

(SAQA, 2000b: 11-12)

The NQF is a framework (see Table 2.1) on which standards and qualifications, agreed to by the education and training stakeholders throughout the country are registered. The framework came into being through the SAQA Act (No. 58 of 1995, Government Gazette No. 1521, 4 October 1995), which provided for the development and implementation of a NQF.
The role of the NQF has become identifiable within the transformation processes happening in the public and private sector domains.

The NQF is described as *a means for transforming education and training in South Africa* and has been designed to:

- combine education and training into a single framework, and to bring separate education and training systems into a single, national system;
- make it easier for learners to enter the education and training system and to move and progress within it; and
- improve the quality of education and training in South Africa.

Table 2.1: The structure of the NQF

NQF LEVEL	BAND	QUALIFICATION TYPE
8 7 6 5	Higher Education And Training	• Post-doctoral research degrees • Doctorates • Master's degrees • Professional Qualifications • Honours degrees • National first degrees • Higher diplomas • National diplomas • National certificates
Further Education and Training Certificate (FETC)		
4 3 2	Further Education And Training	National Certificates
General Education and Training Certificates (GETC)		
1	General Education And Training	• Grade 9 • Abet Level 4 • National Certificates

2.3 POLICY DEVELOPMENT IN MATHEMATICS AND SCIENCE EDUCATION

The evolution of the formulation for policies in mathematics and science education followed separate routes since the mid-1970s through to the late 1980s (Kahn, 1996: 282). Mathematics education followed a politicised discourse partly through the work of the National Education Co-ordinating Committee (NECC) Mathematics Commission. In contrast, science education remained more conservative and static. Numerous initiatives were embarked upon to transform the old mathematics-science separation and to find some form of congruency between the two science-related disciplines. One such initiative was the Science and Technology Education Commission (STEC) that came into being but since none of its members were mathematicians, its policy position paper showed hardly any thinking on mathematics. The Centre for Education Policy Development (CEPD) was brought into the investigation as an independent broker and their work culminated in the publication of the African National Congress (ANC) document entitled " Policy Framework for Education and Training".

Taylor's viewpoint (see paragraph 2.2) that policy context formulation can become overtly political was reflected in the *vis-à-vis* relationship between the CEPD and the ANC government. The mandate and brief given to the CEPD by the ANC in the drawing up of their Policy Framework document on education and training, was to devise a set of plans which could facilitate the implementation of the party's political vision for education and training. The CEPD, together with the assistance of twenty task teams drawn from across the community, helped develop this set of plans.

It was in this Policy Framework document that one could find for the first time explicit mention of the government's commitment towards redress programmes. For students it would be through "second chance" programmes, and for teachers through certificated, accredited in-service training (ANC, 1994: 33).

In September 1994, the then newly-appointed Minister of Education tabled the White Paper on Education. Section 32 of the White Paper (SA, 1994) highlighted the significance attached to the need to prepare students for subjects in short supply, particularly in mathematics, science and technology. This vision, together with the notion of extending a "second chance" to students, that would otherwise not fulfil the admission requirements to higher educational institutions, was proposed as part of a programme of special measures needed to enable more students to follow science-based careers.

One of the task teams working under the auspices of the CEPD was the task team for science, technology and mathematics education. This particular task team was able to recognise the poor state of the curricula for mathematics and science, as well as the large number of under-qualified and unqualified mathematics and science teachers. Of main concern to this task team was the time it would take to address these problems. According to Kahn (1996: 285), the task team felt compelled to look at the problems from a different perspective. They (the task team) had reached the conclusion that the shortage of qualified mathematics and science teachers, coupled with only a small number of successful school leavers with mathematics and science, were bottlenecking the progress of mathematics and science. He further elaborated on how the task team saw the small cohorts of mathematics and science school leavers as a possible solution. Some of these school leavers, who may have failed or under-performed, were reregistering to repeat the mathematics and science subjects in order to improve on their original marks. Kahn (1996: 285-286) noted that their achievements in repeating these matriculation subjects were "impressive".

The notion of *repeating* thus became firmly entrenched within government and formed the basis to an emerging idea for a student recovery programme linked to teacher development. These redress programmes (in both the recovery and teacher-training phases) were given the acronym "SYSTEM": Students and Youth into Science, Technology, Engineering and Mathematics.

2.4 PREMISE FOR INTERVENTION

From a societal perspective, mathematical competency is essential in preparing students to become mathematically literate and numerate. From a global perspective, mathematics and science are central to all school curricula and reflect the vital role that these subjects play in contemporary society. In particular, by providing an international portrait of mathematics education, one can add to the existing knowledge of the state of mathematics education around the world.

The International Association for Educational Achievement (IEA) was founded in 1959 for the purpose of comparing the educational performance of school students in various countries and systems of education around the world. Its aim was to look at achievement against a wide background of school, home, student and societal factors. In the early 1960s the IEA sponsored the First International Mathematics Study (FIMS), a study devoted to comparative studies of school practices and achievements in mathematics. Much has happened since 1964 when FIMS was carried out. Curriculum reforms and changes in patterns and philosophies in education systems of countries over a generation ago had affected the teaching and learning of mathematics. The necessity of a second study thus became imperative (Travers, Oldham & Livingstone, 1989: 2).

With the IEA having learnt much in the intervening years about the art and science of international survey research, a decision was taken by the IEA Council to undertake a Second International Mathematics Study (SIMS). According to Travers *et al.*, (1989: 4), SIMS focused intensively upon the *context* in which achievement in mathematics took place. SIMS drew on items and questions from FIMS and was able to sketch a change in mathematics teaching and learning over time in several educational systems from different countries.

A Third International Mathematics and Science Study (TIMSS) was conducted in 1995 which involved more than half a million students.

TIMSS was the largest and most ambitious of a series of international comparative studies of educational achievement. Of the 63 countries that participated, only 41 had completed the studies. During the collection of the achievement data in each of the participating countries, TIMSS researchers also developed a wealth of information about teachers and teaching, about curricula and instructional materials and about classroom lessons and interactions (Howie & Hughes, 1998: 14).

South Africa was the only representative from Africa. The Human Sciences Research Council (HSRC) was responsible for conducting TIMSS among 15 000 South African students (Howie, 2001: 12). When the results of TIMSS were first released at a press conference in 1996, the shock of the South African pupils' low performances reverberated around the country for quite some time. Intense debates in the media as well as in educational and political circles followed. TIMSS had certainly brought the issues related to mathematics and science education firmly back to the attention of the policy-makers (Howie, 2001: 3).

In 1998, TIMSS was repeated (TIMSS-R) with 38 countries participating. The study was undertaken to assess the developments that had occurred since TIMSS was conducted. Once again, South African students performed poorly. Less than 0,5% of these students reached the International Top 10% benchmark (that is, the average score achieved by the top 10% of pupils internationally). The mean score for South Africa was 275, well below the international mean of 487. From a province-specific perspective, the Northern Cape and Gauteng achieved the second highest mean score with 318 each. However, from an international perspective this was still significantly below the international mean score (Howie, 2001: 18-20).

To educational policy planners in South Africa, the TIMSS results became a source of constructive motivation for mounting an action strategy to address identifiable problems in mathematics and science education (Howie, 2001: 3). The primary impetus towards the implementation of the SYSTEM project as a redress programme was based, *inter alia*, on the poor achievement in mathematics of our learners in TIMSS.

2.5 THE SYSTEM PROJECT: NATIONAL

Documentation of the SYSTEM project (pre- and post-periods) was limited. The presentation of some statements in this study emanated from first-hand experience through the direct involvement of the author in the project. Reporting of the advocacy and implementation phases was accomplished through referencing minutes of meetings (SYSTEM national and provincial), facsimiles, SYSTEM National documents and site reports. Interpretations (and impressions), noted in this chapter, have been moderated by two colleagues who were involved in the provincial programmes of SYSTEM. The SYSTEM project was a national initiative and was sourced out to the nine provinces in an advocacy campaign. Provinces had to take responsibility for implementing the project.

2.5.1 The SYSTEM Initiative

The vision of a New South Africa is that of a prosperous, united, democratic, non-sexist and internationally competitive country. Allied to this is a vision of a people who will earn their rightful place in history as a literate, productive, gifted and innovative nation. The SYSTEM Initiative[*6] was perceived to be the vehicle in opening the path to the fulfilment of this vision in facilitating excellence in science, technology, engineering and mathematics (SYSTEM Task Team, 1996: 9). The SYSTEM Mission Statement listed the provision of high quality education as its primary objective. The attainment of this objective meant that both the national and provincial education departments had to create innovative, transformative, democratic and open learning processes. The priority was thus to encourage the fullest contribution and strongest commitment of all involved in the SYSTEM Initiative (SYSTEM Task Team, 1996: 9).

The original timeline for the SYSTEM Initiative is represented diagramatically in Table 2.2. This timeline had to be modified on numerous occasions since the SYSTEM Initiative had to contend with a changing policy environment.

[*6] SYSTEM Initiative later became known as the SYSTEM project.

Table 2.2: The original timeline for implementation of the SYSTEM Initiative

1994	1995	1996	1997	1998	1999
Plan SYSTEM legislation	SYSTEM 1 →	SYSTEM 2 Diploma Year 1	Internship at Grades 7/8/9	SYSTEM 2 Diploma Year 3	Internship at Grades 7/8/9
Plan College Diploma	Develop diploma →	Mentor/ INSET development	School: extra Grade 10s	School: extra Grade 11s	School: extra Grade 12s
Curriculum development	Materials development →	SYSTEM 1	SYSTEM 2 Diploma Year 1	Internship at Grades 7/8/9	SYSTEM 2 Diploma Year 3
Plan Mentor development	→	Mentor/ INSET development	School: extra Grade 10s	School: extra Grade 11s	School: extra Grade 12s
Plan INSET/ school delivery	Certification →		SYSTEM 1	SYSTEM 2 Diploma Year 1	Internship at Grades 7/8/9
Funding allocation	→			Mentor/ INSET development	School: extra Grade 10s
Plan evaluation	Evaluation →	Evaluation	Evaluation	Evaluation	Evaluation

(ANC, 1994: 265)

[SYSTEM I later became known as Phase I and SYSTEM II as Phase I]

In seeking to lodge the SYSTEM Initiative within a governmental statutory framework via the Committee of Heads of Education Departments (CHED), the following issues arose at the outset of negotiations in September 1994:

- that the post-1994 national Department of Education had not previously run, facilitated or funded education programmes or projects;
- whether the DoE could run programmes of redress involving school level work, given that the provinces have responsibility for all education other than universities and technikons;
- whether CHED could manage full scale delivery programmes; and
- how the DoE related to initiatives originating outside its structures (the SYSTEM Initiative was still lodged with the CHED).

(Kahn, 1996: 287)

By bearing in mind these ongoing difficulties, further prospects of implementing the SYSTEM Initiative were stalled by the withdrawal of a CEPD task team. This team was originally tasked to develop a curriculum framework for the SYSTEM Initiative. The task team defended itself by citing endless bureaucratic "hoops and rings" in their engaging processes with the incumbent bureaucracy. Kahn (1996: 288) viewed this withdrawal of the task team as a strategy to allow newly-appointed officials to find a way through the bureaucratic obstacles.

With the strategic withdrawal of the CEPDs task team from the SYSTEM Initiative, an official SYSTEM Task Team was appointed on 8 November 1995. The *SYSTEM Initiative* now became the *SYSTEM project*. The task team was charged with the responsibility of providing leadership and for managing the development and implementation of the project. Approval for SYSTEM was sought from the Heads of Education Committee (HEDCOM) and was obtained in April 1995. The incumbent national Minister of Education approved the project on 3 August 1995 and it was gazetted in October 1995.

The vision and mission of SYSTEM now became more certain and the restructuring of programmes (as outlined in Table 2.2) became more focused on the outcomes for:

SYSTEM Phase I: A recovery ("second chance") programme aimed at increasing the number of students with matriculation mathematics and science.

SYSTEM Phase II: A teacher development programme aimed at addressing the acute shortage of qualified and competent science, mathematics and technology teachers.

Coherency for the project became inherent through the formation of a SYSTEM Project Committee consisting of major role players in science, mathematics and technology education in advisory capacities. The Project Committee served as a policy board.

On 6 December 1995, the establishment of working groups, to be co-ordinated by the SYSTEM Task Team, was discussed. On 30 January 1996, the working groups were formally established with most of its members coming from non-governmental structures. The working groups were recognised by HEDCOM on 13 May 1996 only for the purposes of accessing funds for their subsistence and travelling expenses.

The functions of the working groups were to develop:

- syllabi for the SYSTEM Phase I programmes;
- materials to be used in these programmes;
- staff to use the materials mentioned above; and
- the SYSTEM Phase II Framework for the SYSTEM Secondary Teacher's Diploma.

It was deemed essential that these working groups settled in with the principles underlying the constructivist ethos of SYSTEM. They (the working groups) had to ensure that the curricula for SYSTEM would be written with the pledge of following a constructivist methodology that is not only contextually cognitive but would allow for the influence of affective factors (beliefs, attitudes, anxieties, etc.) on the teaching and learning processes (see paragraph 3.1). According to McLeod (1992: 575), affective issues play a central role in mathematics teaching and instruction.

The possibility of government funding for SYSTEM was given an immediate boost through the national Minister of Education's successful bid to control some 40 million rands of funding for new policy initiatives. In 1997, foreign funding was secured for the project from the French government (cf. also paragraph 2.6.1). However, it was felt at that time that if redress was to mean anything to the ANC government, then a prerequisite for ownership of SYSTEM should be the provisioning of funding from the ruling party.

2.5.2 SYSTEM as an intervention process

In 1994 some 450 000 learners wrote the senior certificate examinations. Of these, in the order of 90 000 took mathematics and physical science. The reasons for these unacceptably low take-up and success figures were many, and included:

- Teacher shortage
- Teacher quality
- Gender bias
- Language problems
- Inappropriate textbooks
- Irrelevant syllabi
- Inappropriate assessment methods
- Lack of teacher support
- Weak school leadership
- Disruption of schooling. (ANC, 1994: 259)

In 1999 the number of learners taking mathematics and physical science increased to 442 253. Out of the 281 304 learners who took mathematics in 1999, 159 079 failed (SA, 2001: 20). In 2000 the national pass rate for selected subjects revealed that the lowest pass rate was achieved in mathematics (45,1%) [SA, 2001: 21].

In terms of learner participation in mathematics and science, the data in Table 2.3 revealed a much more troubled situation. Not only was there a decline in enrolments in both higher grade mathematics and physical science, but no dramatic improvements in higher grade performances in the two subjects were discernible.

Table 2.3: Learner performance in the Senior Certificate differentiated along Higher Grades (HG) and Standard Grades (SG) for Mathematics and and Physical Science

NUMBER OF CANDIDATES (Multiply by 1000)									
Subject	Grade	1997		1998		1999		2000	
		Wrote	Pass	Wrote	Pass	Wrote	Pass	Wrote	Pass
Maths	HG	68,5	22,8	60,3	20,3	50,1	19,9	38,5	19,3
Maths	SG	184,2	66,9	219,4	68,6	231,2	72,2	254,5	79,6
P. Science	HG	76,1	27,0	73,3	26,7	66,5	24,2	55,7	23,3
P. Science	SG	65,2	35,2	83,8	43,2	93,5	44,0	125,1	55,1

(Data source: Northern Cape DoE, 2002: 4)

Now, more than ever, the intervention programmes of SYSTEM assumed a more urgent need for redress initiatives. The focus had to be on those learners who had taken mathematics and physical science but had failed or seriously under-performed. The underlying causes for low achievements could be ascribed to those factors outlined in this paragraph. For SYSTEM, by seeking any form of intervention, it was essential that a balance be struck between the demand of equity and the need for human resource development.

2.5.3 Operationalisation of SYSTEM

The fundamental concept of the SYSTEM project was embedded in the principles of redress, access and equity.

The outcomes of the SYSTEM operation were conceptualised as follows:

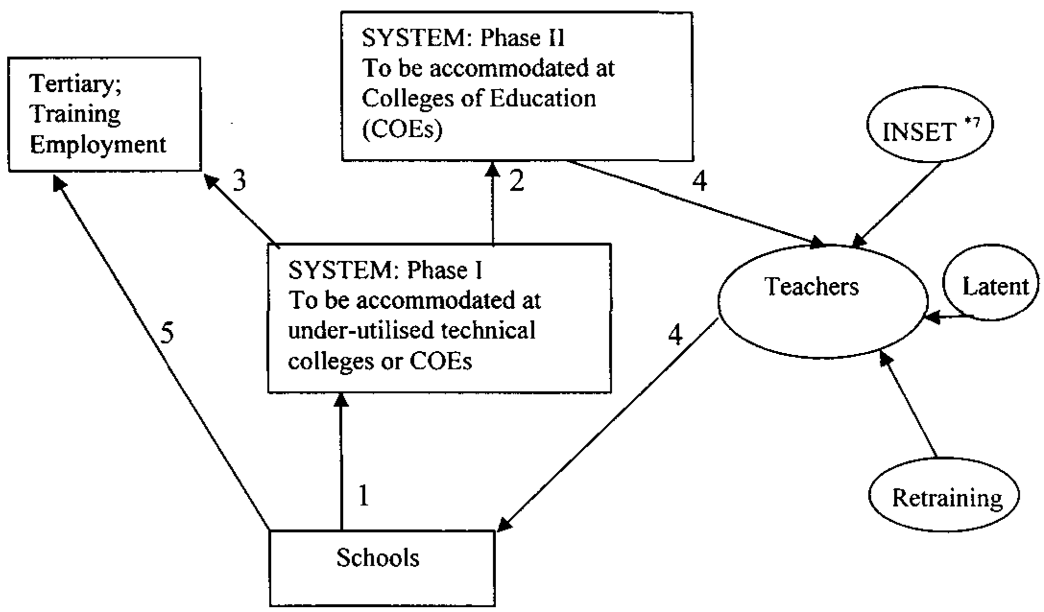


Figure 2.1: The SYSTEM concept (Modified from source: ANC, 1994: 262)

*7 In-service Education and Training.

SYSTEM operated along the routes indicated in Figure 1:

Route 1: students and youth could move into SYSTEM: Phase I for one year;
Route 2: the successful completers from Phase I could move into SYSTEM: Phase II and enter Colleges of Education;
Route 3: or they could enrol at any tertiary institution, training sector or decide to seek employment;
Route 4: SYSTEM students would then enter the schools as qualified mathematics and science teachers, and these in turn could lead to an increase in the number of teachers; and
Route 5: students and youth could directly exit the schools.

The outputs from SYSTEM: Phase I could then proceed in many directions. It was envisaged that State funding would be used to channel up to a quarter of the successful completers into colleges of education to enrol for the SYSTEM Teachers' Diploma (herewith referred to as the SYSTEM Diploma).

The original framework for the SYSTEM Diploma (offered as a full-time course) was:

Year 1: College-based curricula
Year 2: Internship (school-based)
Year 3: College-based curricula
Year 4: Internship (school-based).

The above framework was later modified (see Table 2.6) for reasons outlined in paragraph 2.7.

2.5.4 SYSTEM Phase I: The Recovery Programme

The Phase I (Recovery Programme) was the redress part of SYSTEM. Students admitted to the Recovery Programme must have sat for the national senior certificate examinations. They should also have presented and passed three senior certificate subjects other than mathematics and physical science in one examination sitting. Amongst the three subjects presented for admission, students must have achieved passes in two languages at Higher Grade level, of which one had to be a medium of university instruction. However, from province-specific perspectives, adherence to these admission requirements was not always strictly applied due to the tremendous interest shown in the provinces from students with very poor symbols (symbols ranging from E to H on the standard grade) in mathematics and physical science.

The Recovery Programme was a full-time, one-year instructional programme consisting of six subjects in which instruction was undertaken simultaneously.

The six subjects were:
mathematics, physics, chemistry, life and earth sciences, technology and communication.

The draft curricula for the Recovery Programme subjects were already in place by 1995 and the curriculum development process was overseen by the SYSTEM Curriculum Committee. The committee consisted of the co-ordinators from the working groups (see paragraph 2.5.1). The draft curricula were piloted in 1996 and were further developed in that year. The working groups were not only tasked to develop materials on a modular basis but also to develop constructivistic methodologies that would allow for reflection and innovation of teaching and learning strategies.

On 23 October 1996 a workshop was held in Pretoria between members of the SYSTEM Task Team and the Curriculum Committee. At that meeting the following agreement was reached:

- the development of the curricula had to be inextricably linked to the staff development process (to be arranged by the SYSTEM Task Team). The working groups had to ensure that these links were established in practice;
- the staff development workshops would become subject-focused; and
- on-site workshops should be held at provincial SYSTEM sites on a rotational basis.

(Mphahlele, 1997: 3)

The piloting of the Recovery Programme was structured along a three-year cycle (1997-1999), monitored and supervised by the SYSTEM Task Team (as appointees of the national DoE). It was envisaged that on completion of the cycle, ownership of the project would become a provincial initiative.

Phase I was fully functional in all nine provinces as from 1997 with the initial pilot taking place at the Free State site in 1996. It was expected from the provinces to manage Phase I within a policy environment determined by the national Department of Education.

2.5.4.1 *Further Education and Training (FET)*

The progressive methodologies used by the SYSTEM Curriculum Committees in designing their learning programmes for the Recovery Programme were all convergent towards OBE. Furthermore, the constituency served by the Recovery Programme (1997-1999) would be in the same age and experience range as those in the soon-to-be established FET institutions.

It was envisaged that the linkage of the Recovery programme to the FET programmes could eventually unfold in so far as the similarities of their problems were concerned.

With the pending introduction of an outcomes-based curriculum into the FET band, the following issues were raised about the readiness of the FET institutions with regard to:

- the design features of the curricula, the processes by which they are being developed and the plans for implementing them;
- the consequences on the planned implementation timelines for the cohorts of 2003; and
- whether the FET has learned anything from the review of Curriculum 2005 in the GET band regarding implementation.

(Ndhlovu, 2002: 4)

Like the SYSTEM project, the responses to these issues would inevitably be located in the historical context of curriculum reform since 1994. The problems faced by the FET were not dissimilar to the ones faced by SYSTEM, which had to follow unfamiliar and uncharted processes in order to solve its problems during its conceptual and developmental stages. The Recovery Programme was strategically centred around the OBE approach to education and training and was in line with the developments of the NQF.

SYSTEM, originally viewed by the national Ministry as a "second chance" initiative, could now be elevated to the perspective of enhancing the relevance of FET programmes to work and self-employment (SA, 1998a: 7). It was thus only logical to presume that institutions that deliver the curriculum at the levels of FET would be interested to know what has gone on with SYSTEM (SA, 1998c: 15).

2.5.4.2 *Assessment and Certification*

In October 1996 three of the Recovery Programme's subjects, namely mathematics, physics and chemistry, were approved by the Committee of University Principals (CUP) as satisfying university admission requirements at a level equivalent to two senior certificate subjects at Higher Grade. These three subjects were to be examined externally. The other three remaining subjects, namely life and earth science, technology and communication, were not presented for certification purposes as they were to be examined internally. However, these internal subjects were viewed as being crucial to the development of technofluent individuals, as well as to strengthen individual learning and educational skills, values and understanding.

Assessment within the SYSTEM curricula was brought in line with the NQF principles, and had to adhere to:

- outcomes that are relevant to the mathematics and science learning areas;
- the objectives of SYSTEM; and
- the notion of continuous assessment.

Continuous assessment methods had to incorporate the following:
internal and external examination, practical work, tests, projects, portfolios, presentations and assignments.

A proposal for a certificate of exemption for students of the Recovery Programme was submitted to the Matriculation Board and to the CUP for approval. The executive committee of the Matriculation Board approved the proposal on 15 January 1997. Necessary arrangements were also made with the CUP to issue Certificates of Exemption to students who qualified for university exemption. Arrangements with the South African Certification Council (SAFCERT) for the issuing of Senior Certificates to successful candidates were undertaken. An agreement was also entered into with the Section: National Examinations of the Department of Education to conduct the first final examination in October/November 1997 for the SYSTEM Recovery Programme. Arrangements were made for the appointment of examiners and moderators in order for the new instructional offerings to be examined externally.

Initially, the Independent Examination Board (IEB) would have been responsible for the setting and moderation of the SYSTEM question papers, but with negotiations proving unsuccessful with that body, accreditation was later undertaken by SAQA.

The new instructional offerings were named as SYSTEM Mathematics and SYSTEM physical science (a two-modular structure comprising physics and chemistry).
An aggregate mark for physical science (using the physics and chemistry marks) was to be calculated to reflect the achievement in SYSTEM physical science.

To successfully complete the Recovery Programme, students had to pass with at least 50 percent in both SYSTEM mathematics and SYSTEM physical science. Students were also encouraged to obtain passes in each of the other SYSTEM subject areas, namely life and earth science, technology and communication.

To qualify for a complete exemption certificate (as approved by the CUP) by virtue of a combination of Recovery Programme programmes (the two new externally-examined instructional offerings) and Senior Certificate instructional offerings, students had to:

- Have passes in at least three Senior Certificate instructional offerings, including two Higher Grade languages in one examination sitting, provided that one of these languages was at first language level and provided also that one of these languages was a university language of instruction.
- Have passed the SYSTEM mathematics and SYSTEM physical science with at least 50 percent.

In February 1998, a memorandum from the Department of Education was dispatched to the provincial Ministers of Education detailing amendments to the promotion requirements of the Recovery Programme. Based on the nationwide performance of the 1999 intake of SYSTEM students, it was felt that the stringent requirements were responsible for a very disappointing pass rate.

To rectify the unfortunate position of these candidates it was thus deemed expedient to amend the programme requirements based on the recommendations of the Matriculation Board. This was done by drawing a clear distinction between the requirements for the issuing of a Certificate of Exemption and those for the issuing of a Senior Certificate. The consensus was that the requirements for the issuing of a Certificate of Exemption for university admission would remain as they were, while the requirements for the issuing of a Senior Certificate would be amended to bring it on par with the Senior Certificate requirements in public schools. The SYSTEM candidates for the Senior Certificate were now allowed to obtain a pass requirement of at least 40 percent in both SYSTEM mathematics and SYSTEM physical science (SA, 1998b: 2).

2.5.5 SYSTEM Phase II: The Teacher-Training Programme

In 1996 the TIMSS report revealed that South Africa performed the worst in science and mathematics (Howie & Hughes, 1998: 75). The report further identified some of the weaknesses inherent in the system of education and training in this country. The report listed the following deficiencies:

- the curriculum and pedagogy were too rigid and inappropriate;
- it was found that learners in South Africa had substantially less contact time in the classroom with teachers than did learners in the top TIMSS performing countries; and
- more or less 57 000 more teachers were required for both mathematics and science.

Given this information on the state of mathematics and science education, it was felt that Phase II (the teacher-training programme) could possibly redress some of these concerns. With the acknowledgement by government of the abnormalities brought about by past practices in the education system, it promised changes that were intended to address the issues mentioned in the TIMSS report.

However, with regard to teacher education, problems still existed. The provisioning of "inferior education being offered at colleges" (SA, 1996: 2), as well as the appointments of unqualified and under-qualified teachers in poorly-resourced schools, were still prevalent. In addition, the curricula of many colleges remained static, with the practising of critical thinking and progressive philosophies being shut off from teacher education.

A change in the *status quo* necessitated a shift in policy on teacher education and this culminated in the establishment of the Committee on Teacher Education Policy (COTEP). This committee drew up the Norms and Standards for Teacher Education, which was declared national policy by the Minister of Education on 8 September 1995 (Refer to Government Gazette, No. R1387, 8 September 1995). As a consequence of this policy, the NQF Act envisaged the setting up of the South African Council for the Accreditation of Teacher Education under the auspices of SAQA.

Phase II of SYSTEM was viewed as an interventionist programme in teacher education and its purpose was to address problems that related to:

- low number of qualified and competent science, mathematics and technology teachers
- lack of teacher support
- the unattractive teaching profession
- the need for capacity building
- class, gender and race discrimination
- decontextualising science, mathematics and technology education.

(SA, 1996: 2)

By offering the SYSTEM Diploma, it was perceived that this effort would attempt to address the acute shortage problem of suitably trained mathematics and science teachers (Mphahlele, 1997: 9).

The curriculum of Phase II was aimed at producing teachers:

- with a sound base in knowledge, skills, values and attitudes to perform competently in the world of science, mathematics, engineering and technology;
- who were effective in facilitating education in mathematics, science and technology in order to establish and maintain a culture of teaching and learning;
- who were empowered to exert influence so as to break the cycle of mediocrity in science, mathematics and technology education in the ever changing environment; and
- who saw themselves as life-long learners.

(SA, 1996: 10)

The working group on teacher education developed the framework for the SYSTEM Diploma in June 1996. The original framework (see Table 2.2) was approved by COTEP on 1 July 1996, whereafter a consultative process was undertaken to allow various stakeholders in the provinces to debate and negotiate an implementation plan.

It was deemed expedient that if the SYSTEM Diploma were to be successfully implemented, the following aspects had to be addressed:

- staff development for Colleges of Education personnel;
- careful selection of schools for internship placements;
- mentor development in the placement schools;
- curriculum development in the Colleges of Education;
- inclusion of gender studies in the curriculum;

- INSET support to the interns;
- distance education support to the interns; and
- development of post-graduate science and mathematics education programmes for Colleges of Education staff.

(ANC, 1994: 264)

2.5.5.1 *The Project schools*

School selection for the internship placements was a key factor in the SYSTEM: Phase II programme. Once a school had been designated as a project school[*8] and mentor teachers identified, it had to remain so in order to allow for the continuous uptake of SYSTEM interns. Mentorship training and INSET for all the mathematics and science mentor teachers were to be provided for, as part of the entitlement of life-long learning. INSET for mentor teachers was to be school-based and was set to lead to an accredited qualification, possibly a Further Diploma in Education (FDE = now referred to as the Advanced Certificate in Education). The FDE was to incorporate core modules on mentoring and mentorship and the mode of delivery was either via part-time studies or through distance learning (see also Table 4.2 for the planning of the mentorship programme).

During the internship period, the SYSTEM students were expected to:

- support each other by sharing preparation work, sharing tasks in the teaching and learning process, etc;
- observe each other teach, taking notes and give feedback (peer review);
- meet all the other SYSTEM students placed at that school to discuss the day and making observations of their work;
- co-operate with their assigned mentor teacher who in turn will introduce and expose them to the needs of the school and guide them in all aspects of school administration;

[*8] Herewith referred to as placement schools.

- partake in all extra-mural and extra-curricula activities presented by the school; and
- negotiate with their mentor teacher for any changes they (the students) wish to bring about to their lesson planning and presentation.

(Kibi, 1998: 2-3)

According to Olivier (2002: 1), the internship period for the Northern Cape SYSTEM project meant that students:

- were full members of staff at the placement schools;
- would be involved in the full teaching programme and school activities;
- were expected to complete the prescribed observations, assignments and action research;
- had to present lessons in the majors and be evaluated by the lecturers and mentor teachers; and
- had to design work plans for the duration of the internship period in their two major subjects.

Further initiatives in the development of the Phase II involved the drawing up of a proposed Curriculum Business Plan. The business plan was scheduled for implementation at the start of January 1997 extending to December 1997 according to the timelines shown in Table 2.4.

Table 2.4: Proposed Curriculum Business Plan

Date	Timeline For Curriculum Development
January 1997	• develop curricula for the Diploma • visit SYSTEM site in provinces • develop draft course materials for the first year of the Diploma
February 1997	• rework first year curriculum materials for the Diploma courses
March 1997	• submit draft first year course materials for evaluation
April 1997	• accreditation discussed by relevant bodies • certification process discussed further with relevant bodies
May 1997	• further development of materials • formally submit curricula for accreditation to relevant bodies
July 1997	• develop second year curriculum materials • evaluate materials

(Mphahlele, 1997: 7-8)

Assessment for Phase II was similar to those used for the Recovery Programme (see paragraph 2.5.4.2). Assessment methods were in line with the NQF and operated within the knowledge-skills-values paradigm and were in accordance with the aims of the SYSTEM teacher education curriculum.

The development of continuous assessment strategies for Phase II took cognisance of what the National Teacher Education Audit referred to as the high level cognitive skills, independent critical thinking and the application of theory to the South African context (Hofmeyr & Hall, 1995: 92).

Whereas Phase I operated in all nine provinces, only four provinces eventually embarked on implementing Phase II of SYSTEM.
The reasons given by colleges for postponing or cancelling Phase II were:

- that the timing for the implementation was problematic;
- that restructuring / downsizing was happening in the college sector;
- weak logistical support;
- inadequate staffing / staff not suitably qualified;
- lack of provincial support; and
- financial considerations.

(SA, 1998c: 19)

2.6 THE SYSTEM PROJECT: NORTHERN CAPE PROVINCE

The start-up phase for the Northern Cape to implement SYSTEM was in February 1997. Prior to this date the SYSTEM Task Team had visited this province on numerous occasions with the view to advocacy, development and implementation of the project. Meetings were held with the relevant provincial education authorities and role-players. Reciprocal visits to meetings in Pretoria followed and discussions were confined to the logistics in dealing with the implementation plan. Following this development was the appointment of a SYSTEM provincial co-ordinator for the Northern Cape site.

The process of staff selection for the Recovery Programme was initiated and secondments from the College of Education (see footnote * [4]) were made. Non-College of Education staff members were offered contract appointments. Six academic and two non-academic (an administrative assistant and a laboratory assistant) staff members were selected based on an interviewing process under the auspices of members from the SYSTEM Task Team, provincial education authorities and teacher trade unions. A site co-ordinator from within the selected pool of SYSTEM academic staff was appointed.

The physical site for Phase I (the Recovery Programme) in 1997 was the ex-Perseverance College of Education in Kimberley, aptly renamed SYSTEM College: Northern Cape. The selection of this site was based on the consideration of minimal financial implications to both the national and provincial education departments in the development of additional physical resources. With the physical infrastructure and human resources already in place in this province, the allocation of a provincial budgeting code for this project was readily facilitated. In 1999, at the request of the provincial education authorities, the site for the Recovery Programme was relocated to the College of Education.

Student selection for the Recovery programme was in accordance with the admissions requirements outlined in paragraph 2.5.4. However, exceptions to the admission rules were later made to boost dwindling student numbers.

The Recovery Programme in the Northern Cape ended in 1999 after the completion of the 3-year cycle. Reasons for not continuing with Phase I of the project are still highly debatable (see paragraph 2.7 for further comment).

Table 2.5: Student numbers for the SYSTEM project in the Northern Cape

Intake Year	SYSTEM Phase I: Recovery Programme	SYSTEM Phase II: SYSTEM Diploma				
		Year 1	Year 2	Year 3	Year 4	Graduates
		1998	1999	2000	2001	2002
1997	87 →	9(*9) +15(*10) →	22 →	22 →	22 →	15
1998	60 →	No intake for teacher training				
		Non-SYSTEM: Secondary Teacher's Diploma				
		Year 1	Year 2	Year 3	Graduates	
		2000	2001	2002	2003	
1999	60 →	4 →	4 →	4 →	4	
2000	No intake					
2001	No intake					

*9 From Standard 10 (Grade 12) or university (=Group 1).

*10 From the SYSTEM Recovery Programme (=Group 2).

A brief elucidation of Table 2.5 on the SYSTEM Diploma population at the College of Education in Kimberley:

Year 1997: Start of the SYSTEM project in the Northern Cape. 87 students were accepted for the Recovery Programme. Eventually only a handful of students from this year continued into Phase II (teacher training) and enrolled for the SYSTEM Diploma.

Year 1998: The second intake of 60 students for the Recovery programme. Out of the pool of successful completers of the Recovery Programme of 1997, only 15 applicants for the SYSTEM Diploma were accepted for teacher-training. A further 9 students, who had completed Grade 12 a year or more before, and with no exposure to a redress programme, were accepted and enrolled for the SYSTEM Diploma. In their first year of teacher-training, 2 students from the SYSTEM group dropped out of the course.

Year 1999: The third and final intake of 60 students for the Recovery Programme. No students from the 1998 Recovery Programme were selected for teacher-training. Out of the 22 first year students from the 1998 teacher-training intake, one student left and an additional student from a university was directly accepted into the second year of study by virtue of credits obtained from that university.

Year 2000: From the 1999 Recovery Programme intake, only 4 students were selected for teacher-training and followed the College of Education's own instructional offerings, that led to a Secondary Teacher's Diploma instead of the SYSTEM Diploma (for credit allocation, see Table 2.6; also cf. paragraph 2.7).

Year 2001: Completion of studies by the 1998 intake for teacher-training. From this group of 22 students, only 15 managed to successfully complete the requirements of the SYSTEM Diploma course and graduated in 2002 as competent and suitably qualified mathematics and science teachers. This year also marked the phasing-out of Phase II of SYSTEM and the eventual demise of the project.

The remaining 7 unsuccessful students are at present (years 2002-2004) in the process of completing outstanding modules at the College of Education through a special concession granted by the college management.

2.6.1 SYSTEM project funding

The availability of 40 million rands for new policy initiatives and the successful bid by the then incumbent Minister of Education to control the funds, made initial government funding of SYSTEM a reality. Later on (in 1997) foreign funding was secured for the project through a grant from the French government. An amount of 12 million rands was donated, and made available over two years [1998/99 and 1999/2000] (Motala, 1998: 2). Of this amount, 2,75 million rands were allocated to SYSTEM National and 9,25 million rands were divided amongst the nine provincial SYSTEM projects.

Funding information was relayed to the provinces via the SYSTEM National director. A meeting was convened on 31 August 1998 and its aims were to discuss the allocation of the funds and claims procedure. The objectives of the meeting were:

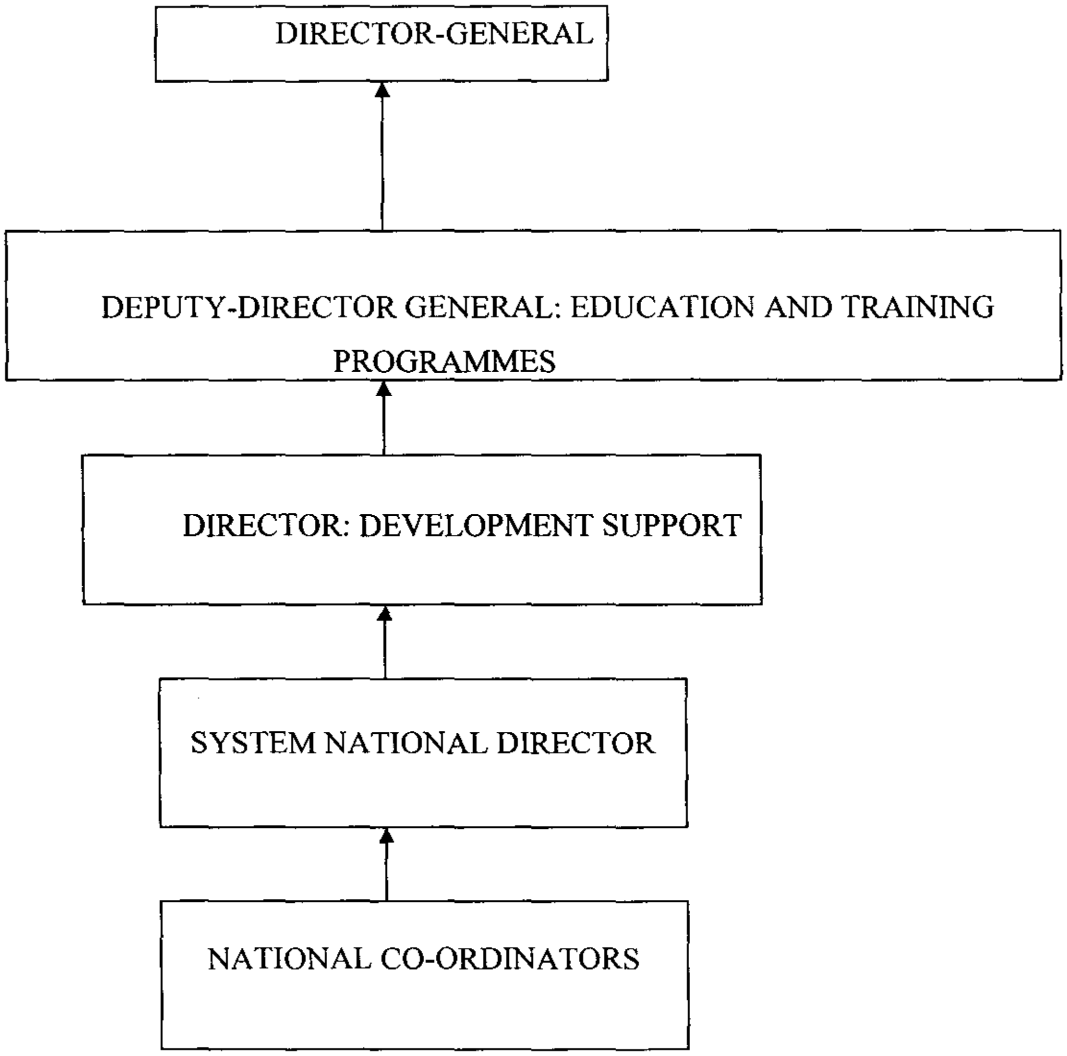
- to present documents relating to the accessing of funds made available to the project by the French government;
- to clear up potential obstacles to the accessing of available funds;
- to understand the claims procedure that had been put in place by the DoE;
- to agree on a mechanism for drawing up a business plan which would essentially serve as a budget, indicating how available funds were to be spent; and
- to agree on time frames for the completion of tasks so that funds could be accessed as soon as possible.

(Motala, 1998: 2-3)

Funding for the Northern Cape amounted to one million rands for both phases of SYSTEM in the 1998/99 financial year.

During the course of 1998, the accounting structure at the Department of Education changed. The SYSTEM Task Team now had to report to the Directorate of Development Support instead of to the Department of State Expenditure (SA, 1998c: 2).

The line function of the accounting structure for the SYSTEM Task Team was now to be:



2.7 PROBLEMS ASSOCIATED WITH SYSTEM

The initial prospect of implementing SYSTEM was based on the realisation that besides the obvious technical preconditions for success, there were two overriding political considerations. The first consideration was the need for political support from the government even though the vision of redress programmes emanated from within government, and the second consideration was for institutional political support and ownership (Kahn, 1996: 286). Against this background began a long process of lobbying and advocacy which resulted in the process being stalled at one stage through the interplay of personalities and movements. It was through a combination of doggedness and luck that opportunities had to be seized which ultimately culminated in the achievement of the first consideration, namely the endorsement of SYSTEM by the then incumbent Minister of Education in August 1995. The second consideration failed to materialise due to the various provinces' failure or reluctance to accept ownership of the project once it had completed its cycle. This development, in conjunction with other factors, ultimately ensured the demise of the SYSTEM project not only in the Northern Cape but in all other provinces.

It was further acknowledged that attempts at implementing SYSTEM in 1995/6 (see Table 2.2) were *ad hoc*, unco-ordinated and unstructured (Mphahlele, 1997: 4).

The SYSTEM Task Team conceded that their initial tenders were absolutely inadequate (SYSTEM Task Team, 1996: 10) and that persistent problems with the State Tender Board were responsible for slowing down the process. It was also noted that the transfer of funds for the project to the provinces seemed to have bottlenecked at the treasury departments of the provinces. A threat was even levied from one province to redirect SYSTEM funds towards other educational needs.

The SYSTEM Task Team listed their concerns about their own status within the project as:

- the ambiguity of being or not being in the employment of the DoE;
- being barred from workshops which they as a task team felt could have benefited them. A case in point was a workshop on teacher audit that possibly could have impacted on the development of the SYSTEM Phase II; and
- the perception that the project had more respect outside than inside the DoE.

(SYSTEM Task Team, 1996: 19)

In the first two years of their contract, the SYSTEM Task Team had to make do without any secretarial assistance in their offices. Numerous requests were also made for an administrative person to assist with communications, secretarial work and filing (SA, 1998c: 3).

In 1998 the SYSTEM Task Team shrank with the departure of its co-ordinator for curriculum and materials development to an appointment within the DoE. Furthermore, the recruitment of the co-ordinator for student selection, staff recruitment and development to a NGO was a further setback to the project. The DoE allowed this person to continue to assist in his original designation on a part-time basis. To compound the staffing problem for the task team, the Finance and Logistics co-ordinator took ill and his absence for most part of the year proved problematic. SYSTEM was now viewed as " a ship being steered by one sailor at times" (SA, 1998c: 3).

From a province-specific perspective, the Northern Cape experienced relatively few problems in so far as human and physical resources were concerned. However, like other provinces, the Northern Cape opted not to accept ownership of SYSTEM.

The framework for Phase II had also proved to be problematic (in its course design) for this province. Notwithstanding the commitment of the college staff in the course deliverance, the Diploma Framework had to be renegotiated with the SYSTEM Task Team. The task team in turn provided a new format for Phase II to this province through their own negotiations with the DoE. Instead of the original Diploma Framework (see paragraph 2.5.3), a modified Diploma Framework (Table 2.6) was approved by COTEP for use in this province. Problems arose at the end of February 1999 with the dissolvement of COTEP. With the request for additional time for the completion of certain modules, further modifications to the Phase II structure eventually had to be negotiated with the college management, the accrediting university and the SYSTEM Task Team.

Table 2.6: Modified SYSTEM Diploma Framework for the Northern Cape

Subject		Credit	Year 1: 1998		Year 2 1999		Year 3 2000		Year 4 2001	
			Sem 1	Sem 2	Sem 3	Sem 4	Sem 5	Sem 6	Sem 7	Sem 8
Education		1	#	#			#	#		
Professional Studies		1	#	#			#	#	#	#
Communication		1	#	#	#	#				
Major 1: Mathematics		2	#	#	#	#	*	*		
Major 2: Physical Science	Chemistry	2			#	#	*			
	Physics								#	#
Major 3: Computer Studies		1	#	#	#	#	*	*		
Internship		1					#	#	*	
Research Project		2					#	#	#	#
Total Credits		11								

(# = COTEP-approved structure; * = additional time needed for completion)

The modified SYSTEM Diploma framework still reflected 11 credits (compared with the 9 credits for the Secondary Teacher's Diploma). The modified diploma offered numerous advantages:

- students stayed longer at the college before they go out to teach (internship);
- by the time the students go on internship, they had completed most of their university accredited modules; and
- the spacing out of the course provided the college and students with more time for delivery and learning, and further allowed students to repeat or complete outstanding module(s).

During the nine-month internship period of Year 3 (see Table 2.6), additional tuition for certain modules were negotiated with the placement schools. Students were expected to return to the college for two full days of tuition per week. The contact sessions were classroom-based and interspersed with a distance mode of delivery.

In Year 4 an additional session of 5 weeks of practice teaching was negotiated to complement the duration of the internship period. The original intention was to have an internship period extending over one year. The funding of an intern stipend, in order to support SYSTEM students at schools, was negotiated with the SYSTEM Task Team. The task team had serious reservations about the financial and political implications of this move, since they (interns) were already recipients of provincial teacher education bursaries. Stipends were nevertheless paid to the practising students.

The envisaged development of the mathematics and science mentor teachers through an accredited INSET certification programme (a proposed FDE) had also not materialised (see paragraph 2.5.5.1), neither had the support promised by task team to upgrade the physical resources of placement schools.

Questions on whether the intentions of the SYSTEM curriculum working groups to develop curricula and materials for the Diploma Framework came to nought, are also debatable (author's contention). The Northern Cape Province eventually had to seek partnerships with other institutions of higher learning to ensure the acquisition of programmes and accompanying accreditation for its SYSTEM Diploma course. The University of the Free State provided the programmes and accompanying accreditation for Mathematics I and II courses, Chemistry I and a Computer Studies course. The remaining programmes for the SYSTEM Diploma were sought with and accredited by the University of Potchefstroom.

The non-publicity surrounding the SYSTEM project with most higher learning institutions in South Africa had also affected its marketability in the provisioning of suitably qualified mathematically- and scientifically-fluent students and neophyte teachers. Failure to deliver on promises had resulted in some difficulty for the successful completers from the Recovery Programmes to access institutions for further learning. A troubling example of this was the failure to deliver the promise in the issuing of Senior Certificates and Certificates of Exemption for university admission.

2.8 CONCLUDING REMARKS

This chapter addressed ***Research Question 1*** about the gestation of SYSTEM within the ambit of transforming the education and training system. Focus was on transformation as a process. The notion of policy transformation within the education sector became apparent, especially in the development of mathematics and science education initiatives. One particular redress initiative was the SYSTEM project. The exposition of this chapter captured, to some degree, the processes of initiation, development, advocacy, implementation and evaluation of the project.

By acknowledging the baseline information collected by TIMSS in 1995 and by TIMSS-R in 1998 about students' achievements in mathematics (see paragraph 2.4), the context of Chapter 3 focuses on providing a theoretical premise for Study orientation in mathematics, Mathematics anxiety, Attitude towards mathematics and Achievement in mathematics.

This contextually historical synopsis also encapsulated one of just many challenges that education had to respond to in a post-1994 South Africa. Both educators and learners are now active participants in the transformation processes. To view education as a moral idea against the background of social justice, government policies and programmes, it is essential that effective teaching and learning take place to ensure that the momentum of transformation in South Africa is sustained.

In concluding, an article about SYSTEM in *The Teacher* entitled "*When failing is winning*" (Pace, 1998: 7), could be aptly paraphrased to refer to the process that the SYSTEM project, notwithstanding the problems associated with it, had started and, with it, the transformation of mathematics and science education.

CHAPTER 3

THE INFLUENCE OF STUDY ORIENTATION IN MATHEMATICS, MATHEMATICS ANXIETY AND ATTITUDE TOWARDS MATHEMATICS ON THE MATHEMATICAL ACHIEVEMENTS OF STUDENTS: A THEORETICAL ANALYSIS

3.1 INTRODUCTION

Over the past years, educational researchers have been exploring new avenues to explain the complex psychological structures and other processes influencing the development of teaching and learning. The work of earlier pioneers of learning and teaching theories has played a significant part in our understanding of the epistemological foundations of mathematics learning and teaching, as well as our understanding of contemporary theories of learning and teaching.

The theoretical premise for teaching and learning in the SYSTEM project

From a South African perspective, there are certain aspects of contemporary theories of teaching and learning that underpin our new educational curricula. Aspects of these theories focus particular attention on increasing the roles and the responsibilities of the learner / student. It is within this educational environment that SYSTEM operated. For SYSTEM, teaching and learning have to conform to a socio-contructivistic style as opposed to the traditional practices of the past (see Table 3.1).

Table 3.1: Learning Views: Traditional versus Constructivist

Traditional Learning	**Constructivist Learning**
Teacher as transmitter	Teacher as facilitator / mentor
Instruction	Construction / discovery
Teacher centred	Learner centred
Absorbing material	Learning how to learn
Limited to school	Life-long
Knowledge	
Transmitted	Constructed
Meaning	
Reflects external world	Reflects perceptions and understanding of experiences
Symbols	
Represents world	Tools for constructing reality
Learning	
Knowledge transmission, reflecting what the teacher knows; product-orientated	Knowledge construction, interpreting world; process-orientated
Teaching	
Simplify knowledge, deductive	Increasing diversity, inductive, coaching and mentoring

Constructivistic theory has been prominent in recent research on mathematics education and has provided a basis for transforming mathematics teaching and learning. According to Simon (1995: 114), students construct their own knowledge of the world from their perceptions and experiences, which are mediated through their own previous knowledge.

The teaching style prescribed by SYSTEM (Northern Cape) for student teachers during the internship was the problem-centred approach (see Appendices J, K, L and M) for mathematics, which is firmly rooted in the socio-constructivitic approach.

For the learning process, focus was placed on the importance of the students' own understanding of their learning orientation as well as on their unique learning characteristics and preferences. Hunt, Matthew and Eagle (2000: 1) argue that students who are not adequately informed about the learning process will not be able to assume some of the responsibilities for their learning, which in turn can affect the learning outcomes. The transformative educational environment prevailing in South Africa, provided the framework for a SYSTEM curriculum that was not only contextually cognitive in design but allowed for other non-cognitive considerations which could influence the teaching and learning processes (see paragraph 2.5.1). From an international perspective, curricula reform efforts in the United States have placed special importance on the role of affective factors in the mathematics curriculum (McLeod, 1992: 575).

Against this contextual background of teaching and learning theories, the aim of this chapter is to present a theoretical analysis of Study orientation in mathematics, Mathematics anxiety and Attitudes towards mathematics in influencing the achievements in the learning and teaching of mathematics (see Figure 3.1). The selection of these variables, for use in this study, was based on research undertaken by Maree, Prinsloo and Claasen (1997: 3) which shows that there was a statistically significant association between aspects of Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics in influencing Achievements in mathematics. The design of the empirical component of this study was not to investigate the correlations between these variables but rather to use them as determinants to detect any significant differences between group perceptions. However, the inter-relatedness of these variables are acknowledged (see paragraph 3.6) in this study in context of their influential roles on the teaching and learning processes. Measurements of these variables (presented in the empirical study) would serve as a predictor of the influential role of SYSTEM Phase I as a conduit into SYSTEM Phase II. The results of the academic achievements and performances of SYSTEM students during institutional learning and field teaching respectively would serve as an assessment base for SYSTEM Phase II (see *Research Question 2b*). Two of the independent variables (Mathematics anxiety and Attitude towards mathematics) were defined and embedded in terms of one of the three main domains of educational outcomes identified by Bloom (1956), namely the:

Affective domain – outcomes that emphasize a feeling, an emotion (essentially focussing on, *inter alia*, beliefs, attitudes, interests, anxieties, values and emotions) [Adapted from Moodley, 1981: 2].

McLeod (1992: 576) states that Simon (1982) suggests that *affect* be used as a more general term and that other terms (for example, beliefs, attitudes and emotions) be considered as more specific descriptors of subsets of the affective domain.

This chapter concludes by alluding to the remediating nature of mentorship in ameliorating the factors affecting performance and achievement.

Schema outlining the constructs and variables used in this study:

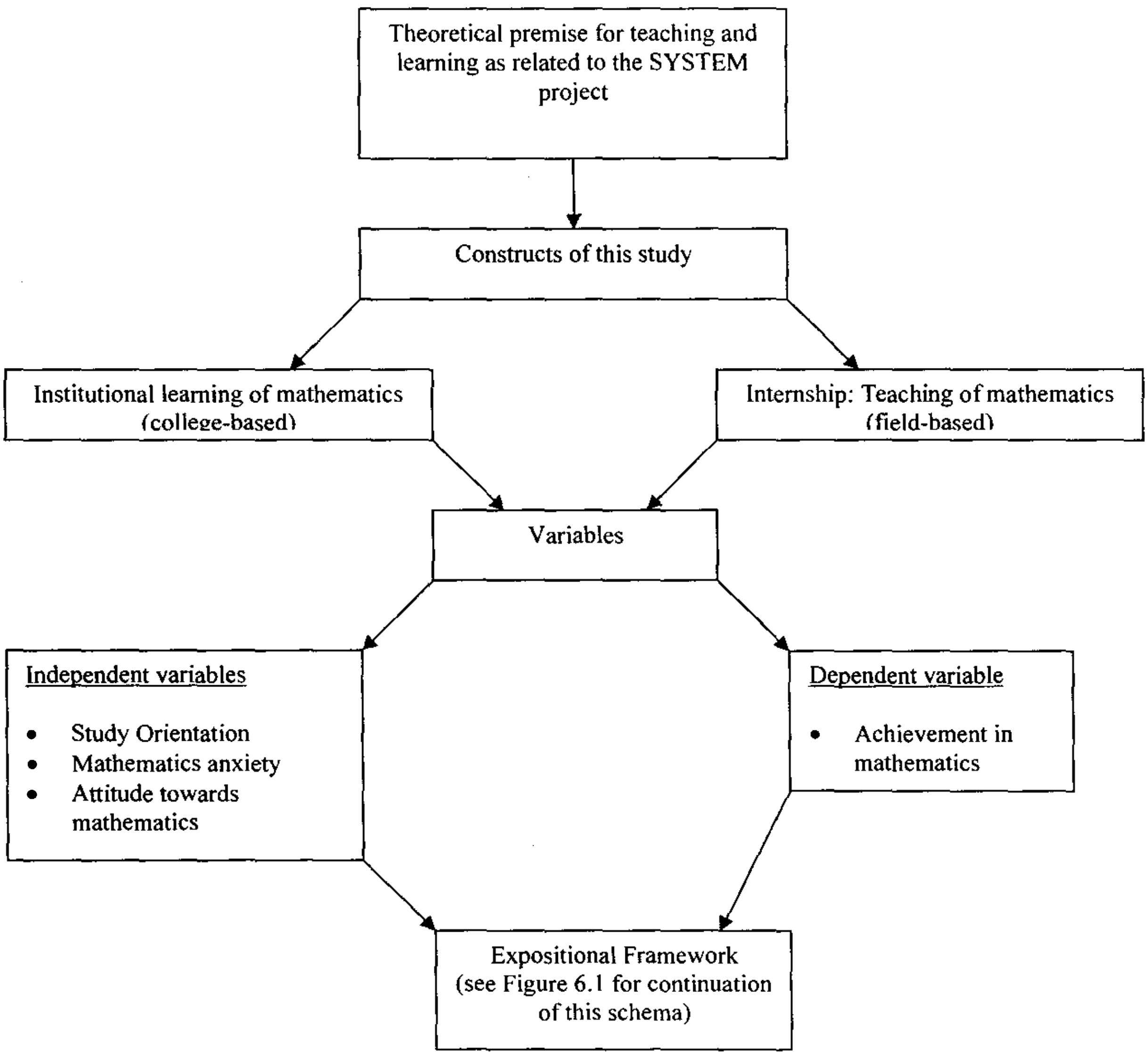


Figure 3.1: Hierarchy for the delineation of the fields of measures

3.2 STUDY ORIENTATION

3.2.1 Introduction to Study orientation

Purdie, Hattie and Douglas (1996: 87) list many common themes about student conceptions of learning, such as learning for increasing ones's knowledge, learning as a duty, learning as memorising, learning as reproducing knowledge and learning as studying. Hunt *et al.* (2000: 1) argue that students who are not adequately informed about the learning process will not be able to assume some of the responsibilities for their learning, which in turn can affect the success in achieving the learning outcomes. Successful learning can be described as a continuous process of regeneration, whereby existing knowledge and skills are used to build new knowledge and skills. Martinez (1997: 3-4) describes successful learners as being serious, committed, self-managed and life-long learners. He states that by the end of the 1970s many educational texts started using words like metacognition, cognitive styles and learning strategies, even though Brown (1987: 65) suggests that terms like metacognition and cognition are too fuzzy, broad and imprecise to use for scientific inquiry. However, researchers and educators continue to pursue different avenues to seek explanations describing the factors affecting performances and achievements.

The emergence of a constructivist paradigm throughout the 1970s held new promise for exploring the relationship between the educator and the learner (Hunt *et al.*, 1995: 2). Students are no longer regarded as passive recipients but as active agents (see Table 3.1), and can now be recruited into taking more responsibility for their learning effectiveness. It allows teachers to have a clearer idea of how students are oriented towards studying.

3.2.2 Defining Study Orientation

Du Toit (as quoted by Maree *et al.*, 1997: 1) refers to the concept of studying as a:

> *Relatively protracted application to a topic or problem for the purpose of learning about the topic, solving the problem, or memorising part or all of the presented material.*

Du Toit further states that there is a distinct indication of acquired behaviour which can be measured with a view of maximising a learner's study orientation.

CPED (1995: 567) defines orientation as a:

> *Mental or physical determination of one's position with regard to a situation.*

Study orientation focuses on the approaches, from varying perspectives on the pedagogy (the practice of how, what and when) of learning (Figure 3.2).

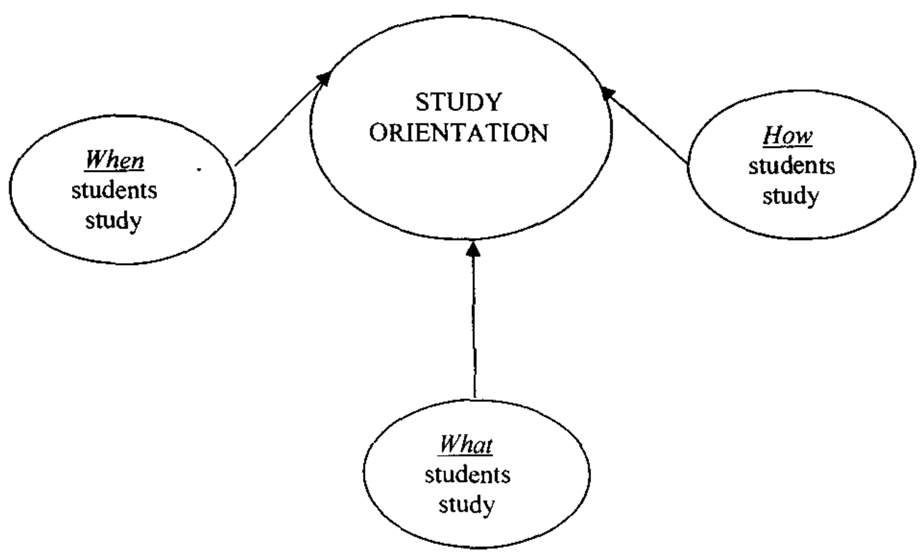


Figure 3.2: Conceptual understanding of study orientation

For the purpose of this study, the definition of Study orientation considers the generic (comprehensive) influences on students' learning. It includes those aspects of studying that can be controlled by students or accommodated by teaching staff (that is to say the factors that are meaningful to students' orientation towards their studies). Magnusson and Svensson (2000: 6) posit that learning orientation is connected to Studying orientation. Attempts to identify distinct types of Study orientations for use in this research have yielded several theoretical approaches.

Marton and Säljö (1984: 38) distinguish between two types of approaches:

1. The *deep*-approach which is oriented towards understanding.
2. The *surface*-approach which is oriented towards memorising.

Biggs (1985: 187) elaborates on the *deep* and *surface* approaches by suggesting they involve strategies for manipulating content in learning tasks. Biggs states that some researchers have discussed a third approach, termed the *achieving*-approach, which "describes the ways in which students organise the temporal and spatial contexts in which the task is carried out".

Ramsden (1992: 83) presents four alternative orientations to studying:

- *Meaning* orientation: students have a deep-holistic approach, use data critically and learn for the sake of learning.
- *Reproducing* approach: students focus on memorising, avoid work that is not mandatory and lack confidence.
- *Strategic* orientation: students seek for clues to what will be assessed and are highly confident and competitive.
- *Non-academic* orientation: students organise work poorly, become easily frustrated and draw upon unsubstantiated conclusions and generalisations.

Ramsden (1992: 82) states that learning outcomes are inter-related with approaches to Study orientation and the pedagogical aspect of the learning context.

Meyer (1988: 73) reports on the relationship between approaches to study and student perceptions of learning context. He observes the important association between *meaning* and *reproducing* orientations, and the learning context (notably those involving specific aspects of the curriculum and methods of teaching and assessment).

The initial intention to identify the different types of Study orientations of the SYSTEM students, using the Study Orientation in Mathematics (SOM) questionnaire, were abandoned based on correspondence with the author of the SOM questionnaire (see paragraph 3.2.3 & Appendices N and O).

3.2.3 The Study Orientation in Mathematics (SOM) questionnaire

The need to measure students' perceptions towards Study orientation in mathematics is based on the premise that mathematics is particularly vulnerable to poor teaching and very little attention is given to the students' orientation towards studying mathematics (Maree *et al.*, 1997: 1).

The SOM questionnaire was designed for South African learners from Standard 5 (Grade 7) to Standard 10 (Grade 12).

According to Maree *et al.* (1997: 5), the following essential features were taken into consideration when compiling the SOM:

- the content had to be meaningful to the testee;
- the questionnaire must have diagnostic value;
- item biases towards language, race, gender and socio-economic environment had to be limited; and
- mark allocation had to be objective.

The aims of SOM were:

- identifying students' negative Study orientation in mathematics; and
- analysing the data obtained that could help counsellors and mathematics educators to obtain a better understanding of students' poor achievement in the subject.

The SOM could be used as:

- a diagnostic tool for identifying those students who need support, remediation and counseling; and
- an aid to make a systematic analysis of a number of important background particulars, feelings, attitudes, habits and customs with regard to the pupil's academic orientation in mathematics.

(Maree *et al.*, 1997: 6)

The fields of SOM:

Maree *et al.* (1997: 6) describe the problem-centred approach (see Appendix J) to the Study orientation in mathematics as one of the primary premises of SOM. The problem-centred approach is specifically aimed at maximising problem-solving behaviour in mathematics. Maree *et al.* (1997: 7-9), identify the following six fields of the SOM:

1. Study attitude towards mathematics

   This field comprises 14 questions and has a bearing on feelings (subjective, but also objective experiences) and attitudes (towards mathematics and aspects of mathematics). Attitude includes various factors like enjoyment of the subject, self-confidence, usefulness of the subject and the challenges it offers.

2. Study habits in mathematics

This field comprises 17 questions and includes:

- displaying acquired, consistent, effective study methods and habits (like planning time, preparation, working through previous tests and exam papers, etc.);
- the willingness to do mathematics consistently; and
- the extent to which pupils promptly complete assignments and tasks in mathematics.

3. Problem-solving behaviour in mathematics

This field consists of 18 questions and includes more cognitive and metacognitive learning strategies in mathematics.
The field includes: planning, self-monitoring, self-evaluation, self-regulation and decision making during the process of problem solving in mathematics.

4. Study milieu (environment) in mathematics

This field considers the different environments and backgrounds pupils come from. Non-stimulating environments (for learning and studying) and limited experiences can cause problems in the ability of learners to achieve. Language problems can also undermine performance.

5. Information processing

This field consists of 16 questions and includes general and specific learning, summarising and reading strategies, critical thinking and understanding strategies.

6. Mathematics anxiety

This field comprises 14 questions. Panic, anxiety and concern are manifested in, *inter alia* aimless and repetitive behaviour.

[Author's note: Mathematics anxiety and attitude are dealt with as separate measurable entities in this study and are not inclusive to the fields of MA-SOM-T (cf. also paragraphs 3.3 & 3.4).]

It was the initial contention of the author that the items in SOM allowed one to ascertain, to a certain degree, whether SYSTEM students exhibited *deep* or *surface* orientation towards studying. However, in email correspondence with Maree (see Appendix O), it was pointed out that SOM was not developed to differentiate between *surface* and /or *deep* orientation(s). Neither was it intended to differentiate between the alternative orientations presented by Ramsden (see paragraph 3.2.2). Maree suggests that one should stick to the fields of the SOM, even though he suspects high correlations between some of the fields in the SOM with some of the fields in other questionnaires measuring study and learning orientations. In an earlier email correspondence (see Appendix N) it was pointed out that a SOM questionnaire applicable to tertiary level students was still in the process of being developed (the SOMT). Steyn and Maree (2002: 7) note that in the SOMT the terminology would be adapted to represent a tertiary environment. In both SOM and SOMT the six fields, identified earlier in this paragraph, would be used and would include 92 statements that relate to how individuals feel or act regarding aspects of their achievement in mathematics.

Steyn and Maree (2002:13) report on an action research done during 2000-2001, involving first-year engineering students in an extended study programme of the School of Engineering at the University of Pretoria. These two researchers posit that SOM and SOMT could be regarded as significant predictors of performance in mathematics.

3.2.3.1 *The Modified and Adapted Study Orientation in Mathematics-Tertiary (MA-SOM-T) questionnaire*

At this stage of the study, with the SOMT questionnaire still under development, the author adapted and modified the SOM questionnaire for a tertiary environment. In particular, only items relevant to the study were selected from SOM. A few additional items were included for the purpose of ascertaining the effects of Study orientation on the mathematical achievement of SYSTEM students.

This questionnaire was appropriately designated as the MA-SOM-T[*11] (referring to the *M*odified and *A*dapted *S*tudy *O*rientation in *M*athematics for *T*ertiary level) questionnaire (=SQ 4)[*12] [see Appendix A].
[Acknowledgement of copyright for the original exemplary SOM items and fields is assigned to the Human Sciences Research Council (HSRC, 1996: Cat. Nos. 3439/E and 3440/E).]

The purpose of the MA-SOM-T was the same as that for the SOM, namely, to gain insight into the reasons why certain students displayed a positive (good) Study orientation in mathematics whilst other students displayed a negative (poor) Study orientation in mathematics within an institutional setting.
Like the SOM, the usefulness of the MA-SOM-T questionnaire was limited by its dependence on honest answers from the students and the avoidance of the Hawthorne effect.

[*11] For purposes of this study only, the changed SOM is now referred to as the MA-SOM-T.

[*12] Student Questionnaire.

The five fields selected for the MA-SOM-T (see paragraph 5.2.3.1) were:

- Study habits in mathematics
- Peer company
- Time
- Content
- Emotional orientation.

Content validity (see paragraph 1.3.2.4) of the MA-SOM-T questionnaire was undertaken through limited student participation (a sample was drawn from non-SYSTEM pre-services student teachers) to validate the fixed-response items. Any anomalies were discussed with the students and the outcomes of the discussion were used to make modifications to the selected fixed-item statements of the MA-SOM-T questionnaire.

The scoring scale of the MA-SOM-T questionnaire was the same as that for SOM and was not affected by the adaptations and modifications.

With the MA-SOM-T having being adapted and modified from the SOM, it is the contention of the author that a standardised MA-SOM-T could also serve as a significant predictor of tertiary level performance in mathematics.

3.3 MATHEMATICS ANXIETY

3.3.1 Introduction to Mathematics anxiety

Anxiety is defined as "being distressed about some event" (CPED, 1995: 31). A number of theoretical conceptions have been developed in attempts to explain the origins or causes of anxiety disorders. These disorders are characterised by high levels of apprehension in the presence of certain objects or situations and by the development of behavioural patterns to avoid these stimuli. The original Freudian theory of anxiety was that undischarged libido was sufficient to cause anxiety. Therefore, simple changes of sexual patterns would seem adequate to cure anxiety. However, modern psychoanalysis view anxiety as being based on two fundamental psychological concepts: psychological conflict and unconscious mental processes (Nemiah, 1981: 354). According to Sarason, Davidson, Lighthall, Waite and Ruebush (1960: 15), anxiety should be viewed in terms of psychoanalytic theory. This view proposes that a child's behaviour in a wide variety of settings is constantly being evaluated by his/her parents.

Adverse parental evaluations often evoke feelings of hostility in the child which cannot be expressed because of the child's dependence on his/her parents for approval, direction and support. Instead, feelings of guilt and anxiety are aroused in the child who appears as dependent, aggressive, and self-regulatory in test-like situations. Schwarzer, Van der Ploeg and Spielberger (1982: 3) posit that anxiety generally refers to an unpleasant emotional reaction that results from the perception or appraisal of a particular situation deemed as threatening. According to Gaudry and Spielberger (1971: 10), much of the early experimental work on anxiety followed the development of the Manifest Anxiety Scale (MAS) of J.A. Taylor (1951) and the subsequent publication of this scale in 1953. These authors report that the MAS was stimulated by the work of the learning theorist K.W. Spence at the University of Iowa.

3.3.2 Defining Mathematics anxiety

In the mid-1970s, Sheila Tobias popularised a term called *mathematics anxiety*. The term was used to describe the debilitating, seemingly irrational emotional response that many people experience when they are required or expected to perform some mathematical task (Tobias & Weissbrod, 1980: 63). McAuliffe and Trueblood report (as quoted by Bessant, 1995: 328) that mathematics anxiety could only moderately be correlated with state and trait anxiety.

State anxiety is an emotional state or condition that is characterised by perceived feelings of tension, apprehension and nervousness. In contrast, trait anxiety refers to the differences between people in their tendency to respond to situations perceived as threatening. Individual differences in state and trait anxiety can be measured by the State-Trait Anxiety Inventory (STAI) questionnaire developed by Spielberger, Gorsuch and Lushene in 1970. The STAI is a useful tool for assessing anxiety in experimental investigations and in clinical practice (Schwarzer *et al.*, 1982: 4).

Further definitions of mathematics anxiety include that of Posamentier and Stepelman (1990: 210):

> *Mathematics anxiety can be defined as a state of discomfort that occurs in response to situations involving mathematical tasks that are perceived as threatening to a learner's self-esteem. In turn, these feelings of anxiety can lead to panic, tension, helplessness, fear, distress, shame, inability to cope and loss of ability to concentrate.*

According to Kelly and Tomhave (1985: 51), mathematics anxiety is regarded as the feeling of fear, avoidance and dislike when dealing with mathematical situations. Bessant (1995: 327) contends that mathematics anxiety has become a euphemism for poor performance, low self-confidence, fear of failure and negative feelings towards mathematics.

Perhaps the most widely used and accepted definition of mathematics anxiety is "feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972: 551).

In other contemporary studies, researchers have identified and examined underlying causes and significant relationship dealing with mathematics anxiety [Cramer & Oshima (1992: 18-35); Karp (1991: 265-270); Pajares and Kranzler (1995: 192-203); Yee (1988: 317-333)]. Studies done by Maree (as quoted in the HSRC Report, 1997) identify, *inter alia*, language problems, other than mother-tongue instruction, to cause anxiety in mathematics and undermine performance in the subject. Kontogianes (as quoted by Vinson *et al.*, 1997:5), after having examined pre-service student teachers' mathematics anxiety, found that a self-paced programme linked with some degree of mentoring positively affected the pre-service student teachers' mathematics achievement and attitude towards mathematics. A detailed explanation of the pharmacologic treatment of anxiety is not within the purview of this study. However, the author makes reference to the process of mentoring, within an educational context, which could help to alleviate or reduce mathematics anxiety (see Chapter 4).

In this study, mathematics anxiety is defined as the emotional reaction and tension that result from the perceptions or appraisals during the institutional learning and the field teaching of mathematics. No classification of mathematics anxiety in terms of state and trait anxiety is made.

3.3.3 The Mathematics Anxiety Rating Scale (MARS)

The Mathematics Anxiety Rating Scale (MARS[*13]) is a 98-item inventory designed as a diagnostic or screening tool for use in treatment and research and intended to measure mathematics anxiety. The MARS is a self-rating scale in a five point Likert format. Scores on each MARS item represent the level of anxiety reported for a specific situation. Selection of scores range from 1 = representing "not at all anxious" to 5 = representing "very much anxious".

[*13] Copyright assigned to R. M. Suinn, Department of Psychology, Colorado State University, USA.

An overall mathematics anxiety score is achieved by summing the individual item scores. Richardson and Suinn (1972: 552-553) report that the MARS instrument has a high test-retest and internal consistency reliability. Cronbach's Alpha coefficient of internal consistency for the total scale was a 0,97 value. Moreover, the 98-item scale is composed of brief descriptions of behavioural situations that may give rise to different levels of anxiety in people being tested. According to Alexander and Martray (1989: 149), the MARS has been the prevailing instrument for measuring mathematics anxiety since its publication in 1972.

Rounds and Hendel (1980: 141) use factor analysis to explore the dimensionality of the MARS. Factor analysis is used to study the patterns of relationship among many dependent variables, with the goal of discovering something about the nature of the independent variables that affect them, even though the independent variables are not measured directly. The inferred independent variables are called *factors*. One of the primary considerations in using factor analysis involves deciding how many factors to extract from the data. At present, factor analysis of the MARS also includes several peripheral factors bordering on the association with earlier identifiable factors. Rounds and Hendel (1980: 142) extract two factors, namely:

1. Mathematics Test Anxiety: associated with anticipating, taking and receiving mathematics test. This label is perhaps too limited, since a significant number of items classified under this factor involve course or class-related activities.

2. Numerical Anxiety: deals with practical, everyday situations requiring number manipulation, basic arithmetic skills or monetary decisions.

Resnick, Viehe and Segal (1982: 39) identify a further three factors in the MARS:

1. Evaluation Anxiety
2. Arithmetic Computational Anxiety
3. Social Responsibility Anxiety

Ferguson (1986: 146) claims to have isolated a unique component of mathematics anxiety dealing with more abstract topics in mathematics. He uses factor analysis to prove that this new dimension of mathematics anxiety, namely Abstraction Anxiety, is distinct from other anxiety factors.

According to Bessant (1995: 328), the MARS has proven to be a reliable measure of *some* dimensions of mathematics anxiety, but does not encompass the entire range of meanings implicit in this concept. Most researchers identify two or three dimensions in the MARS. However, Bessant (1995: 333) states that a researcher named Cattell inferred that there was "no true number of factors to extract" from the MARS.

The present analysis of the MARS includes six factors because of their potential importance in expanding the conceptual and empirical meaning of mathematics anxiety.

The six factors are:

1. General Evaluation Anxiety
2. Everyday Numerical Anxiety
3. Passive Observational Anxiety
4. Performance Anxiety
5. Mathematics Test Anxiety
6. Problem-solving Anxiety.

Mathematics test anxiety is cited as one of many dimensionalities of mathematics anxiety. To remove any ambiguity between mathematics anxiety and test anxiety, researchers such as Dew, Galassi and Galassi (1983: 446) report that the concept of mathematics anxiety and test anxiety are not interchangeable and that much of student mathematics anxiety is due to test anxiety.

Schwarzer *et al.* (1982: 3-4), define test anxiety as a situation-specific trait anxiety. These researchers posit that test anxiety contains a cognitive component called "worry" and an affective component called "emotionality".

Several instruments have been designed to assess worry and emotionality. The Test Anxiety Inventory (TAI) was developed by Spielberger whilst the Test Anxiety Questionnaire (TAQ) was constructed by Mandler and Sarason in 1952 to measure the anxiety reactions of adults taking course examinations or intelligence tests (Gaudry & Spielberger, 1971: 12).
Other scales could also be used to measure mathematics anxiety. One such particular scale (as cited in Norwood, 1994: 248) is the Fennema-Sherman Mathematics Anxiety Scale (MAS).

In keeping with the definition of mathematics anxiety used in this study, the following anxieties are used as sub-scales (see paragraph 5.2.3.2) within the construct of:

<u>The institutional learning of mathematics</u>: Mathematics test anxiety and General evaluation anxiety.

<u>The teaching of mathematics during internship</u>: Performance (teaching) anxiety.

3.3.3.1 ***The Modified and Adapted Mathematics Anxiety Rating Scale (MA-MARS)***

The instrument used to measure the perceptions towards mathematics anxieties of SYSTEM students in this study, is defined by the acronym MA-MARS which refers to the *M*odified and *A*dapted *M*athematics *A*nxiety *R*ating *S*cale (=SQ3) [see Appendix B].

In adapting and modifying the MARS questionnaire of Suinn (1972), several redundant items were deleted from the original instrument, most of which referred to everyday applications of mathematics. A small number of items was also modified to remove explicit reference to the United States' units of measure.

The MA-MARS has a total of 20 items and are categorised within the following sub-scales:

- Mathematics Test Anxiety: associated with anticipating, taking and receiving mathematics test.

- Performance (teaching) anxiety: the emphasis being on observing others (learners, educators, etc.) and performing mathematical tasks (teaching) in the classroom (Bessant, 1995: 335).

- General evaluation anxiety: emphasizes completing of assignments, reading textbooks, preparing for mathematics lessons (Bessant, 1995: 334).

The choice of these three factors was based on the consideration that the items contained within these factors (see Appendix B) best describe the linkage with the constructs of *institutional learning of mathematics* and the *teaching of mathematics during internship.* The MA-MARS was used as a benchmark (as part of the empirical investigation) to ascertain the perceived mathematics anxieties that SYSTEM students have towards the constructs of this study.

Content validity of the MA-MARS questionnaire was undertaken through limited student participation (a sample was drawn from non-SYSTEM pre-service student teachers) to validate the fixed-response items. Any anomalies were discussed with the students and the outcomes of the discussion were used to make modifications to the selected fixed-item statements of the MA-MARS questionnaire. The suitability of the MA-MARS questionnaire for use at college level is viewed against the contention expressed by Bessant (1995: 328) He posits that because of the multi-dimensional character of the MARS, items that consider additional components or themes could be appended to the scale. These items in turn should indicate a proneness to anxiety in a broad range of situations.

The scoring of the MA-MARS questionnaires was not affected by the adaptations and modifications. The scale used ranged from 1 = strongly disagree to 4 = strongly agree.

The complexities of mathematics anxiety cannot be limited to factors identified in the MARS and used in MA-MARS. Some of the meanings of mathematics anxiety can be linked to their similarity to other concepts in the affective domain (such as beliefs, attitudes and emotions).

3.4 ATTITUDE TOWARDS MATHEMATICS

3.4.1 Introduction to Attitude towards mathematics

In the context of mathematics education, feelings and moods, confidence, frustration and satisfaction are all used to describe responses to mathematical tasks. Often these feelings are defined as attitudes, although the term does not seem adequate to describe some of the more intense emotional reactions that occur in mathematics classrooms. McLeod (1992: 581) defines *attitude* as the affective responses that involve positive or negative feelings of moderate intensity and reasonable stability. He reports that many researchers in differential psychology and social psychology have given substantial attention to the notion of affective issues, especially to the study of attitudes.

3.4.2 Defining Attitude towards mathematics

Ernest (1988: 290) defines *attitude towards mathematics* as a combination of the degree of students' liking of the subject and confidence in their mathematical ability. The reason for measuring *Attitude towards mathematics* in this study is the strong belief that attitudes affect the achievements of students in any field of study. Several studies have indicated a strong bond between attitudes and academic achievements (e.g. Knaupp, 1973: 9; Husèn *et al.*, 1974: 292).

According to McLeod (1992: 581), attitudes towards mathematics appeared to have developed in two different ways. One was from the automatising of a repeated emotional reaction to mathematics. The other was the assignment of an already existing attitude to a new but related task.

For purposes of this study and relevancy to the research design, the following definition was adopted and modified from Aiken (1970: 551).

> *Attitude is a learned predisposition or tendency on the part of an individual to respond positively or negatively to mathematical tasks (learning mathematics and teaching mathematics)*

3.4.3 Attitude scales

According to McLeod (1994: 638), one of the major concerns of earlier research on attitude was the quality of the instruments that were being used. He states that some instruments focused only on one attitude dimension. Concerns for the multi-dimensionality of attitudes toward mathematics led Sandman (1980) to publish a Mathematics Attitude Inventory with six scales. Other attitude instruments have also been developed (see e.g. Haladyna, Shaughnessy & Shaughnessy, 1983) but the most influential measures of all have been the Fennema-Sherman Mathematics Attitude Scales. Although the Fennema-Sherman attitude scales were developed for the purpose of research on gender-related differences in mathematics achievement, their impact was felt widely in all research on attitude towards mathematics (McLeod, 1994: 639).

The IEA Study uses the following items in its attitude scale:

Views about mathematics teaching
Views about school learning
Attitudes towards mathematics as a process

Attitudes about the difficulties of learning mathematics
Attitudes towards the place of mathematics in society
Attitudes towards school and school learning
Attitudes towards man and his environment.

(Husèn, 1967: 109-122)

Aiken (1979: 229) designed a four-component Likert-type questionnaire based on the fact that attitude towards mathematics was composed of several dimensions. The sub-scales are:

Enjoyment of mathematics
Motivation in mathematics
Importance of mathematics
Freedom from fear of mathematics.

Moodley (1981: 90) investigates attitudes towards mathematics in terms of the following six sub-scales:

Mathematics teaching
School learning
Difficulties in learning mathematics
Place or importance of mathematics in society
School and Life in general
Enjoyment of mathematics.

For purposes of this study, an attitude questionnaire (see paragraph 3.4.3.1) was designed which focused on the constructs of the research design. No distinct differentiation was made as to the more specific descriptors of the subsets of attitude towards mathematics, as done by researchers in this paragraph. The primary sub-scales of the attitude questionnaire were embedded within the construct of institutional and field settings.

3.4.3.1 *The Attitude towards mathematics questionnaire*

A two-component Likert-type questionnaire of 10 items was used to measure the perceptions of SYSTEM students' attitudes towards mathematics.

The two-component sub-scales considered in SQ1 (see Appendix C) were:

1. Attitudes towards institutional learning of mathematics.
2. Attitudes towards the teaching of mathematics during internship.

The two-component sub-scales were decided upon because of the division in the curriculum structure of SYSTEM Phase II between institutional learning and field practicum.
The attitude rating scale used ranged from 1 = strongly disagree to 4 = strongly agree.

Content validity of the *Attitude towards mathematics* questionnaire was undertaken through limited student participation (a sample was drawn from non-SYSTEM pre-service student teachers) to validate the fixed-response items. Any anomalies were discussed with the students and the outcomes of the discussion were used to make modifications to the selected fixed-item statements of the attitude questionnaire.

3.5 MATHEMATICS ACHIEVEMENT

3.5.1 Introduction to Mathematics achievement

Achievement in mathematics could be viewed from a two-fold perspective. Firstly, it is a *fait accompli* that some teaching methodologies are not apt to increase students' achievement in mathematics.

Secondly, the improvement in the teacher's qualifications in mathematics may not necessary benefit the learner. Educators should be encouraged to focus not only on the cognitive aspects of teaching mathematics but also on the influence of affective factors on the learning process. For the SYSTEM project, the curriculum was not only contextually cognitive in design but allowed for other non-cognitive considerations which could possibly influence the teaching and learning of mathematics (see paragraph 2.5.1).

Knowledge that other contributory factors, *inter alia*, socio-economic and socio-political exert a considerable influence on student achievement is vital. Grobler (1998: 5) ascribes pre-1994 socio-political factors to poor achievement in mathematics amongst Black students. Low socio-economic status and detrimental educational conditions contributed to Black students starting their education in mathematics with a distinct disadvantage. Maree (1995: 47) posits that environmental factors were to be blamed for the poor results in mathematics in the Black schools. Many recommendations to overcome the deficit in mathematics achievement stress the importance of instituting changes to facilitate students' interest in the subject.

3.5.2 Defining Mathematics achievement

In defining *achievement*, this study has embraced its generic definition that pertains to the act of performing, attaining and accomplishing. In this study, a clear distinction is made between educational achievement in institutional (examination mark) and field (internship mark) offerings. The allocation of physical marks (summative) is referred to as *physical (academic) achievement* (see paragraph 6.2.4). For purposes of this study, general achievement in mathematics education is referred to as *mathematics achievement*.

3.5.3 Mathematics achievement questionnaire

An open-ended questionnaire was constructed to elicit the perceptions that SYSTEM students have about their *achievement in mathematics* (=SQ2) [see Appendix D]. The questionnaire was designed to reflect achievement in both institutional and field settings.

The two-component sub-scales of SQ2 were:

1. Achievement in the learning of mathematics.
2. Achievement in the teaching of mathematics.

Limited student participation in completing SQ2 was undertaken to validate open-response items in terms of relevancy and non-ambiguity. The participants were non-SYSTEM students. Any anomalies were discussed with the students and the outcomes of the discussion were used to make minor modifications to the items in the questionnaire.

3.5.4 Some predictors of Mathematics achievement

The design of the Mathematics achievement questionnaire does not make explicit reference to the predictors that could possibly influence SYSTEM students' achievement in institutional learning and field teaching. However, some variances in these students achievement in mathematics could be ascribed to the influences of certain cognitive and affective predictors. Some of the open-ended questions (see Appendix D) of the questionnaire are pegged in the domains of the predictors listed below.

Self-Concept (as an affective predictor):

Definition: According to Bandura (as cited in Grobler, 1998: 10), the self-concept is the individual's perception of his or her self-worth. Jacobs and Vrey (1982: 22) describe the self-concept as "die oortuigings omtrent die self, sy identiteit, sy rolle en vermoëns". Reynolds and Walberg (1992: 308) define self-concept as "students' beliefs that they can determine their own learning success".

Predictor: A person with a positive self-concept will be motivated to achieve success, whilst a negative self-concept can give rise to feelings of inadequacy and anxiety.

Open-ended questions (see Appendix D) relating to self-concept (see also paragraph 6.2.4):

- Describe one of the most important achievements you think you have made in your study of mathematics at college.
- What qualities do you think a mathematics student must possess in order to succeed in mathematics?

Bester (1988: 167) states that a person can form more than one self-concept in more than one academic situation. According to Grobler (1998: 17) the (general) academic self-concept can be sub-divided into a self-concept for every subject that the pupil is taught at school. The subject-specific self-concept that is utilised in mathematics is the mathematics self-concept. Marsh, Parker and Barnes (1985: 442) posit that there is a moderate correlation between the academic self-concept and the mathematics self-concept.

Numerous studies have found a significant positive correlation between mathematics self-concept and mathematics achievement (Bester, 1988; Mellet, 1987). Mellet (1987: 111) finds the mathematics self-concept to be the best predictor of mathematics achievement.

Self-Efficacy (as an affective predictor) (see also paragraph 6.2.4):

Definition: For Bandura (as cited in Grobler, 1998: 18), self-efficacy reflects what a person believes he or she can do with the skills in his or her repertoire. Schunk (1981: 93) defines self-efficacy as judgements of one's capability to perform given activities.

Predictor: According to Shiomi (1992: 563), children with high self-efficacy are likely to be more motivated and are more likely to achieve high marks than children with low self-efficacy.

Open-ended questions (see Appendix D) relating to self-efficacy:

- What special aspects of your mathematics education have prepared you for teaching?
- What would you describe as your weakness as a mathematics student?

Hackett (1985: 47) finds self-efficacy to be a major predictor of mathematical achievement. This researcher states that self-efficacy seems to exist at the core of mathematics anxiety. Norwich (1987: 385) posits that children with higher self-efficacy scores also had higher mathematics self-concept scores. He finds that the self-efficacy role as a predictor of mathematics achievement diminishes if mathematics self-concept is not taken into consideration.

Mathematical ability (as a cognitive predictor) (see also paragraph 6.2.4):

Definition: Mathematics ability refers to the application of basic mathematical reasoning, algorithmic and problem-solving skills.

Predictor: Mathematics ability can serve as a predictor of the level of mathematical proficiency students attempt to master. According to Schiefele and Csikszentmihalyi (1995: 176) mathematical ability is strongly related to mathematics achievement.

Open-ended questions (see Appendix D) relating to mathematical ability:

- Do you think you were adequately prepared at college to achieve success in the teaching of mathematics lessons at school?
- In your observation of mathematics lessons, how would you compare your teaching style with that of an experienced mathematics teacher?
- What planning and preparation did you have to do in order to achieve your outcomes in a mathematics lesson?

Norwich (1987: 384) states that mathematics self-concept can be regarded as a good index of self-perceived mathematics ability. The linkage between self-efficacy concerns to mathematical ability is consistent with findings reported by Hackett (1985: 55). Spielberger (1971: 124) reports that anxious students with average ability obtained lower marks and fall within a higher percentage range of academic failures as opposed to non-anxious students of comparable ability. Students of low ability earn low marks irrespective of their anxiety levels.

Cognisance is also taken of other predictors that could possibly have had an influence on the achievement levels of SYSTEM students.

Interest in mathematics (as an affective predictor):

Definition: *Interest* can be defined as a curiosity or a desire to participate (CPED, 1995: 433). Reference is made to *interest* when a student attributes high value to a particular subject area (Schiefele, 1991: 299).

Interest in mathematics can be viewed as a subject matter-specific factor of motivation (Schiefele & Csikszentmihalyi, 1995: 164).

Predictor: Results from a study conducted by Schiefele and Csikszentmihalyi (1995: 174-177) suggest that the positive relation between interest and achievement is revealed by the fact that interest in mathematics is a significant and independent predictor of how far a student has progressed. These researchers find that interest is a moderate yet significant predictor of achievement. However, they state that ability is the best predictor of achievement.

Intelligence (as a cognitive predictor):

Definition: Vernon (1979: 51) states that intelligence refers to the more generalised skills, strategies of thinking, and overall conceptual level, which apply in a wide range of cognitive activities or in new learning.

Predictor: Grobler (1998: 41) cites the opinions of Fehrmann, Keith and Reimers (1987) that intelligence is the best predictor of (general) academic achievement. According to Schoeman, intelligence is the best predictor of mathematics achievement (as cited by Grobler, 1998: 42).

Gaudry and Spielberger (1971: 79) report a moderate but consistent negative relationship between anxiety scales and various measures of intelligence. This has led some psychologists to suggest that the low achievement levels of highly anxious students can be explained in terms of their lower intelligence. There are, however, a number of factors which suggest that this hypothesis is not viable and that high anxiety evoked by stressful situations is the casual factor which interferes with effective performance.

Socio-economic environment:

Definition: Refers to the social and economic status or environment. This environment is influenced by a number of factors, *inter alia*, family wealth, family size and structure, occupation(s) of parent(s), parental behaviour, etc.

Predictor: According to White (1982: 462-463), material wealth seemed to be a good measure of socio-economic status, but was not the measure that had the largest influence on general academic achievement. White finds that there is a significant positive relationship between measures of academic achievement and measures of socio-economic status.

Crane (1996: 305) reports a positive correlation between mathematics achievement and socio-economic status, whilst Fitz-Gibbon (1985: 43) finds that these variables do not correlate.

Semester grades can also be used as a predictor of mathematics achievement (Schiefele & Csikszentmihalyi, 1995: 170).

The quality of experience when doing mathematics can be used as a predictor of mathematics achievement.

According to Reynolds and Walberg (1992: 306), prior achievement in mathematics and home environment influence subsequent achievement in mathematics most powerfully. Motivation, exposure to extramural reading media, peer environment and instructional exposure also have significant influences on mathematics achievement.

Crane (1996: 313) finds that parental education correlates with general academic achievement.

Monk (1994: 125) finds that a teacher's education has a large influence on pupils' mathematics achievement especially if the teacher was relatively inexperienced. He also finds that the influence that the teacher's experience has on mathematics achievement varies with the age of the pupils. In grade 10 the teacher's experience had no significant influence on the pupils' mathematics achievement, while it had a significant influence in grade 11.

Grobler (1998: 127) reports that gender differences in favour of boys were found in mathematics achievement and that the significant predictors of mathematics achievement differ for boys and girls.

Alpert and Haber (1960: 207) report on the construction of the Achievement Anxiety Test (AAT) to identify individuals whose academic performance is facilitated by the stress of the test situation, as well as those whose performance is impaired.

3.6 INTER-RELATED ASPECTS BETWEEN THE VARIABLES USED IN THIS STUDY

The inter-relatedness of the variables in this study with other peripheral factors influencing the teaching and learning of mathematics has been reported upon earlier (see paragraphs 1.1, 3.2, 3.3, 3.4 & 3.5). The following researchers present findings that are relevant to a broader peripheral scope to this study:

Mathematics anxiety and Study orientation

Bessant (1995: 330-331) posits that mathematics anxiety can be linked to some aspects of study orientation, especially when superficial studying strategies (rote memorisation) are concerned. He states that inquiries into study orientations could form an important theoretical link explaining mathematics anxiety (Bessant, 1995: 343). Steyn and Maree (2002: 1) show that analysis of data obtained from SOM reveals that students of the participating group entered tertiary education with mathematics anxiety and a history of inadequate study environments.

Mathematics anxiety and Attitude

A study undertaken by Bessant (1995: 342-343) investigates the inter-relatedness of various types of mathematics anxiety with attitudes towards mathematics, learning preferences, study motives and study strategies. He reports that factor analysis indicated that, much like mathematics anxiety; attitudes towards mathematics and preferential orientations to learning should be treated as multi-dimensional phenomena. Students' attitude towards mathematics appeared to be intertwined with the facilitating and debilitating effects of mathematics anxiety. He further states that mathematics anxiety could be associated with reading, studying, thinking about and using a wide range of mathematical skills (Bessant, 1995: 336). Hembree (1990: 46) reports a strong association between mathematics anxiety and attitude. He reports on a study undertaken that showed an unfavourable attitude regarding mathematics linked to high incidences of mathematics anxieties among pre-service student teachers.

Anxiety and Achievement

Gaudry and Spielberger (1971: 7) posit that the varying levels of anxiety (verbal reports, physiological indications and general behaviour) can interfere with academic achievement. These researchers (Gaudry & Spielberger, 1971: 19-21) also report that:

- high anxiety is generally associated with low achievement;
- teachers see the highly anxious student as being more poorly-adjusted, and as possessing more negative personality characteristics; and
- parents of highly anxious students see their children as less well-adjusted.

Koran and Koran (1984: 793) report that material that is well-organised should result in better achievement for high anxiety students. According to Gaudry and Spielberger (1971: 42), at college level there is evidence that anxiety tends to be associated with low marks and high dropout rates due to academic failure. Studies undertaken by numerous researchers have found that mathematics anxiety correlates negatively with achievement in mathematics (Richardson & Suinn, 1972; Gliner, 1987; Hembree, 1990; Coleman, 1991). Norwood (1994: 251) reports a slightly negative relationship between mathematics anxiety and achievement in mathematics.

Achievement in mathematics and Study orientation

The actual measuring of students' study orientations could become a good predictor of achievement in mathematics. Maree *et al.* (1997: 3) support this contention and strongly suggest that their SOM will become a good predictor of achievement in mathematics since it correlates high enough with achievement and diagnostic tests in mathematics. Chang (1994: 233) finds that there is a statistically significant correlation between students' study orientation and students' academic achievement.

Paulsen (1970: 6-8) from the Danish Institute for Educational Research cites the findings of the following researchers:

- Gibbons and Savage (1965) report on the positive correlation between the number of home-study hours and examination results gained at the end of the year.
- Malleson (1960) finds no positive correlation between home-study-time and achievement, whilst Thoday (1957) reports a positive relation between the number of hours of home study and achievement. Furthermore, Paulsen (1970: 15) reports that in his own study he found no sex differences with regard to study habits. None of the students in his study sample mentioned their study orientation as a possible contributing factor of importance.

Study orientation and Attitude

Charles and Lester (1984) [as quoted in Maree *et al.*, 1997: 2] state that many students with a negative study orientation in mathematics display a negative attitude towards the subject.

Attitude and Achievement

Minato and Kamada (1996: 96) state that educators need to be aware of the relationship between attitude and achievement and that an attempt needs to be made to determine the causal predominance between these two variables in their bi-directional effects they have on each other. Several studies have indicated a strong bond between attitudes and academic achievements (Husèn, Fagerlind & Liljefors, 1974: 292; Knaupp, 1973: 9).

Study orientation in mathematics, Attitude, Anxiety and Achievement

Maree, Prinsloo and Claasen (1997: 3) state that there is a statistically significant association between aspects of study orientation in mathematics and achievement, attitude and anxiety.

Mathematics anxiety and other related factors

Spielberger (1980: 2) reports that mathematics anxiety was significantly related to traits measured by the TAI.

Rosenberg (1953: 285) reports a strong negative relationship between self-esteem and anxiety, supporting the inference that anxious students hold themselves in low esteem.

According to Lussier (1996: 828), students with a strong mathematical background should be less anxious than the ones from a weak mathematical background.

Lupkowski and Schumacker (1991: 50), in their study on mathematically talented college students, show that the groups of talented students were less mathematics anxious than most unselected college students.

Researchers such as Teh (1996), Teo (1997) and Kor (1997) find no significant gender difference in mathematics anxiety. This finding is consistent with the earlier findings of Resnick *et al.* (1982: 46) and Richardson and Suinn (1972: 554). Gardener (1997) reports that the only statistically significant differences detected in her study, were in mathematics anxiety by gender and a combination of mathematics anxiety and attitude by age. She finds that females had higher levels of mathematics anxiety than males and while older students appear more mathematically anxious, they also reflected a more positive attitude about mathematics. Betz (1978: 447) used a modified version of the Fennema-Sherman Mathematics Anxiety Scale (MAS) to investigate mathematics anxiety in college students. The investigation revealed that females were more anxious about mathematics than males at college level. This finding was supported by further research done by Alexander and Martray (1989: 143), and Bander and Betz (1981: 312).

Bush (1989: 507) posits that teachers who possess a high degree of mathematics anxiety actually teach differently than teachers who are less anxious about mathematics. Greenwood (1984: 663) states that the "explain-practice-memorize paradigm" is the primary cause of mathematics anxiety. This statement supports other studies undertaken that show that teachers unintentionally generate feelings of mathematics anxiety in their students through their teaching strategies. In addition, Jackson and Leffingwell (1999: 583) posit that teacher behaviour is the main cause of mathematics anxiety.

Gourgey (1992: 10) states that the nature of mathematics might be another causative consideration influencing mathematics anxiety. Studies by Schoenfeld (1988: 145) revealed that beliefs about mathematics could cause anxiety about mathematics. Some of the myths, misconceptions and beliefs about mathematics include:

- aptitude for mathematics is genetic;
- to be good at mathematics one has to be good at calculating;

- mathematics require logic, not creativity;
- in mathematics it is always important to get the right answer; and
- men are naturally better than women at mathematical thinking.

Waritay (as cited in Norwood, 1994: 250) finds that students with high mathematics anxiety preferred a highly structured, algorithmic course to a less structured, conceptual course in developmental arithmetic. Similarly, Clute (1984:56-57), Tobias (1989: 213) and Bessant (1995: 338) recommend that highly anxious students should receive clear and structured instruction. Cronbach and Snow (1997: 2) state that the anxiety experienced by an individual depended on the difficulty of the task. A complex task was more likely to create anxiety in persons of low ability than in more able persons.

Gaudry and Bradshaw (1970: 1) studied the interaction between anxiety and methods of assessment. They have found that an increase in emphasis on formal examining places high-anxious students at a disadvantage relative to the less anxious. The introduction of progressive assessment techniques favours high-anxious students.

3.7 CONCLUDING REMARKS

This chapter concludes by conceding that there are many factors that can influence the learning and teaching of mathematics. The theoretical premises presented for variables such as Study orientation in mathematics, Mathematics anxiety, Attitude towards mathematics and Achievement in mathematics of students were explored. The inter-relatedness of the variables, together with its associations with other peripheral factors was noted.

The MA-SOM (SQ4), MA-MARS (SQ3), Attitude questionnaire (SQ1) and the Achievement questionnaire (SQ2) were developed within the framework established by the theoretical premises, albeit that some questionnaires were modified and adapted to be conducive for use at tertiary level and in accordance with the aims of this study.

Present educational reforms in South Africa provide the ideal opportunity to initiate curricula transformation where the focus in the curricula is not just contextually cognitive but consider the affective components, as well as other considerations, that have been shown to influence the teaching and learning processes. By implementing procedures and strategies specifically designed for improving and / or remediating students' study orientation, attitude and mathematics anxiety, as well as related factors such as self-concept, self-efficacy, mathematics ability, etc., can have a significant impact on their achievements in mathematics.

One such strategy is discussed in Chapter 4 and it involves the notion of mentoring. Within the purview of this study, mentoring is considered as a possible strategy in remediating and ameliorating variances in student achievements. The nature and structure of the mentoring process for SYSTEM are fully outlined in the next chapter.

CHAPTER 4

THE SIGNIFICANCE OF MENTORSHIP TO SYSTEM: A REMEDIAL AID FOR VARIANCES IN STUDENT PERFORMANCE AND ACHIEVEMENT

4.1 INTRODUCTION

The teacher-training structure of SYSTEM Phase II, like other teacher-training programmes, was based on the conventional structure of first theory then practice (see also Table 2.6). The relationship between theory and practice in teacher-training is often viewed by students to be problematic. In an interview with the SYSTEM Diploma Students (2002), the most frequent concern expressed by this group of students was the lack of relevance between educational theory taught at college and what actually happens in classroom practice. Handal and Lauvas (1987: 4) view the relationship between theory and practice as being dialectical. It is their contention that the practice period should be placed in the teacher-training programme for a specific purpose in order to bridge the gap between the two spheres of theory and practice. However, one of the main objectives of the SYSTEM teacher-training programme was to make educational theory relevant to practical training. This was achieved through an elongated period of continuous field practicum, namely an *internship period*. The integration of theory with practice formed the basis that allowed the professional development of SYSTEM students to be intrinsically linked to the practice of *mentoring*.

By virtue of the teacher's experienced interpretation of classroom theory and practice, the provisioning of *coaching* by such an experienced person was envisaged by SYSTEM to provide *guidance* to the pre-service students to act as professionals during their 9-month tenure of the internship at the placement schools.

The aim of this chapter is to provide the theoretical underpinnings for the processes of mentoring and mentorship. The significance of mentoring to SYSTEM is explored by eliciting the perceptions of the mentor and mentee (the person being mentored) through interviews. Qualitative analyses of the responses are presented. The chapter concludes by alluding to the nature of the relationships between the mentor / mentee and the effect mentoring has on students' perceptions of their performances.

4.2 THE CONCEPT OF MENTORING

The notion of mentoring is ancient and its first historical reference is found in the eighth century B.C. in a Greek epic poem. In Homer's epic poem *The Odyssey*, the King of Ithaca, namely Odysseus, sets off into a battle (the Trojan War) that would last for ten years. Odysseus leaves his son Telemachus under the wing of his trusted and wise friend Mentor. Mentor developed a one-to-one relationship with Telemachus, guiding him and educating him during his father's absence. Ever since then, mentoring has played a significant role in the annals of human development and has flourished throughout the history of education. An image of what mentoring is *not*, comes from another Greek myth about Procrustes who lived in a cave and invited visitors in for a sumptuous banquet, with lots of wine. At the end of the evening Procrustes would invite his tired and emotional visitors to stay for the night. If a visitor was too short for the bed, Procrustes would then put him/her on a rack to be stretched till they fitted better. If they were too long, he would chop off the parts hanging over the end of the bed. The moral of this story is that mentoring offers a rich and sumptuous banquet. There are many different aspects of life and work that can be focused upon and it is not the task of the mentor to cut people down to size. Mentoring is not a Procrustean bed.

The mentoring process was born from the world of business. Its growth was seen in many professions, none the least in teaching. Mentoring is becoming more central to the development processes in organisations and fields of discipline where it is used. It is different from other processes because it emphasizes and encourages changes in the lives of its participants. Exciting trends are happening in mentoring. Since the application of mentoring techniques is spreading well beyond the corporate parameters, its versatility makes it easily adaptable to most learning and teaching environments. Today, the concept of mentoring has found application in virtually every form of learning. Mentoring has become a popular vehicle to interact with young persons, share expertise and challenge learners to new heights of excellence (Srivastava, 2002: 2). Not only is mentoring linked to the education and training of skills amongst learners and students, but also to the professional development of educators.

In this age of information, communication and technology, classroom pedagogy is shifting from the model of the teacher being an information provider to a more dynamic situation in which the learners and students are able to access information from several other sources or technologies to construct their own knowledge. So too, has the definition of mentoring shifted over time. A traditional mentoring model is the apprentice learning from the master. In the Industrial Age, mentoring focused on career advancement within organisational hierarchies (Haney, 1997: 212). Now the Information Age demands a wide range of cognitive, interpersonal and technical skills and mentoring is changing to cope with these expanded needs (Srivastava, 2002: 3).

4.2.1 Defining mentoring

Most definitions of mentoring are vague and broad and range from:

- being a nurturing and coaching process;
- sharing knowledge and experience;
- work at building trust and acceptance; and

- understanding people's fear

to:

- being an effective vehicle to improve instructional practices of beginning teachers; and
- providing a conceptual framework for intervention strategies;

(Stallion & Zimber, 1991: 425)

- enhancing the mentor's own psychosocial development and growth; and

(Schulz, 1995: 57)

- a transactional process of learning that highlights the interpersonal interaction between the mentor and the mentee; this is characterised by the collaborative participation in the educational experience and mutual reflection about the process and results of learning.

(Cohen, 1995: 16)

Mentoring is thus not an enterprise for those who prefer to work alone, either as individuals or as organisations. Partnerships are the *sine qua non* of an effective mentoring process. Simply stated, mentoring is about one person helping another person. One of the major purposes of mentoring is to maximise positive learning by not to simply and inappropriately shield the mentee, but to reduce the negative cost of trial-and-error learning.

4.2.2 The role of the mentor

Mentors are not tutors or substitute teachers but rather professionals interacting with junior colleagues or students. Mentors act as advisers, consultants and role models and sometimes as critics where this facilitates the mentee's performance.

Ideally a mentor should have:

- knowledge/ expertise in the relevant area;
- experience in the relevant area;
- willingness to guide mentees;
- good interpersonal skills;
- patience and enthusiasm;
- the ability to be a good listener;
- willingness to share what he/ she knows in a non-competitive manner; and
- the time to conduct the activities involved in the mentoring relationship.

(Srivastava, 2002: 5)

Furthermore,

- the mentor serves as a role model for the mentee;
- the mentor exhibits certain dispositions that help with the mentoring process;
- the mentor is a counsellor and friend;
- the mentor assists with the career development of the mentee; and
- the mentor gives direct professional guidance, provides structured opportunities for learning and actively engages in non-threatening evaluative feedback.

(Back & Booth, 1992: 37)

Gardiner (1995: 49) identifies the following mentor-specific skills and states that the art of mentoring is knowing which of the following skills are applicable and in which order of priority:

- active listening
- empathy
- counselling
- negotiation

- coaching
- advocacy
- problem-solving
- decision making
- reflection and review
- constructive feedback
- interpersonal skills
- verbal and non-verbal communication.

In teacher-training, the role of the mentor becomes more defined in terms of educational pedagogy (see also paragraph 4.3.2).

4.2.3 The role of the mentee

A mentee is a person who is in need of mentoring. Ideally a mentee should:

- be eager to learn;
- be open to new ideas as well as criticism;
- respect the mentor's time;
- share problems and concerns;
- set realistic time frames;
- be receptive to feedback and take follow-up actions; and
- express appreciation of mentor support.

(Srivastava, 2002: 6)

4.2.4 Types of mentor-mentee relationships

Mentoring can be a one-off intervention or a life-long relationship. It can be carried out informally, as part of a friendship, or formally, as part of a highly structured new teacher-training programme. Table 4.1 illustrates the four possible types of mentor/mentee relationships. One of the essential qualities associated with mentoring is trust, which is considered fundamental to the development of a successful mentoring relationship. As with most relationships of significance, the nuances of the early connection between mentor and mentee can be of special importance. The interpersonal skills of the mentor are important in establishing the early foundation for a framework of mentor-mentee interaction. Responsive listening (verbal and non-verbal reactions that signal sincere interest), non-judgemental sensitive responses (to help clarify emotional reactions) and descriptive feedback (based on observation rather than on motivation) are just a few mentor behaviours that can have a positive influence on the mentor-mentee relationship.

Table 4.1: Types of Mentor / Mentee relationships

SHORT-TERM MENTORING	LONG-TERM MENTORING
1. Highly-structured, short-term mentoring	**1. Highly-structured, long-term mentoring**
The relationship is formally established for an introductory period or short period, often to meet specific objectives. For example, a new teacher may be paired with a more experienced teacher.	This sort of relationship is often used for successor planning, which involves grooming someone for a job.
2. Informal, short-term mentoring	**2. Informal, long-term mentoring**
This type of "off-the-cuff" mentoring ranges from the once-off spontaneous help to the occasional assistance or counselling. There may not be an ongoing relationship	This form of mentoring sometimes called "friendship mentoring" consists of being available as a mentor on a casual or "as-needed" basis over a long period of time.

(Winberg, 1999: 13)

The mentee will respond to and rely on the observable behaviours of the mentor as the indicator of internal intentions or motives (Cohen, 1995: 29). If a mentor has a negative predisposition or a listening style that is viewed by the mentee as distant or aloof, then the mentee may quickly become withdrawn or non-co-operative. This may severely hamper the expectations of the potential value of the mentoring relationship. A mentor who is too rigid can cause a mentoring relationship from becoming unproductive and can diminish his/her legitimate role "as a guide through some of the perils of the mentee's journey" (Cohen, 1995: 56).

During the evolving mentoring relationship, the mentor and mentee should eventually formulate the plans necessary for achieving the mentee's expressed educational and professional goals. Megginson and Clutterbuck (1995: 18) view the following questions of importance when measuring the effects of a mentoring relationship:

- Have the mentor and mentee established a close rapport?
- Are both the mentor and mentee learning?
- Does the mentee feel more confident in his/her ability to tackle new challenges?
- Has the mentee improved on his/her performance whilst under the tutelage of the mentor?
- What proportion of the mentoring relationship succeeded and what proportion failed?
- Do mentors feel they have sufficient training?
- What skills deficiencies do mentees perceive in their mentors?

An effective mentoring relationship should allow for the mentors to play a role in evaluating their mentees and *vice versa,* with the mentors themselves being held accountable through their mentee's evaluation. The quality of classroom teaching and learning is the bottom line for evaluating the effectiveness of a mentoring relationship.

4.3 THE SIGNIFICANCE OF MENTORSHIP FOR SYSTEM

4.3.1 Introducing the mentorship programme

Prior to 1995, classroom-based support and school-based work were the main areas targeted by INSET programmes that still reflected past, traditional practices of the South Africa education system. In 1995 there was a demand for in-service courses on the implementation of the new curriculum. By this time, some schools had already introduced constructivistic methodologies, such as the problem-centred approach (see Appendix J) in the teaching of mathematics, the communicative approach in the teaching of languages and the new thinking around the teaching of South African history. To many mathematics teachers the new approach in teaching mathematics (the approach became known as the "New Maths") made them feel completely incompetent (Lebethe & Agherdien, 1996: 182), even with their many years of teaching experience in the subject. These teachers were further faced with a wide range of unfamiliar teaching and learning strategies, such as co-operative learning and teaching (the "Buddy System"), learners constructing their own problem-solving techniques, peer interaction amongst learners, peer interaction amongst teachers, etc. DiGeronimo (1993: 348) describes a "Buddy System" in which every new teacher is assigned an experienced teacher who works in the same school. These "buddies" were likened to mentors as they exhibited the same disposition of being well-organised, having good communication skills and demonstrating effective use of teaching strategies. The strategies were a far cry from the traditional paradigms associated with teaching and learning. It was within this milieu that a mind-shift in the thinking of educational classroom practitioners was necessitated. With OBE as a knowledge-constructing strategy and with clearly defined outcomes for learner-learner, learner-educator and educator-educator structures, the potential for the incorporation of formal mentoring into these structures exists (see paragraph 7.8).

Within the constructivist-learning environment of SYSTEM (see paragraph 3.1), mentoring became an integral part of the planning for Phase II and a necessary addition to classroom and school pedagogy. Srivastava (2002: 3) posits that mentoring supports constructivist-learning environments.

The conceptual framework of SYSTEM was set to capture this neo-educational approach. With an education system in favour of OBE teaching and learning in the classroom, SYSTEM focused on introducing a paradigm shift in the traditional teacher-training programmes. Phase II became divorced from past teacher-training programmes by focusing on:

- university accredited courses for the major subjects;
- introducing an action research module;
- providing full-time tuition and distance education during field practice; and
- introducing a year of internship accompanied by a mentorship programme.

Five colleges of education offering Phase II were to be involved in the mentoring programme:

1. Tshiya College of Education (Free State Province).
2. Tivumbeni College of Education (Mpumalanga Province).
3. The Amalgamated Phatsimang and Perseverance College of Education (Northern Cape Province).
4. KwaNdebele College of Education (Mpumalanga Province).
5. Mankwe College of Education (North West Province).

The original student numbers for the SYSTEM: Phase II programme in the provinces are set out in Table 4.2.

Table 4.2: Original numbers submitted in the planning of the mentorship programme

Province	Student Number	Number of Placement schools	Number of Mentor teachers	Number of lecturers
Northern Cape	24 students	11 schools	10 mentors	4 lecturers
Free State	20 students	9 schools	20 mentors	3 lecturers
Mpumalanga	37 students	10 schools	10 mentors	5 lecturers
Mpumalanga	32 students	7 schools	7 mentors	3 lecturers
North West	15 students	4 schools	4 mentors	4 lecturers
TOTAL	128 students	41 schools	51 mentors	19 lecturers

(Source: SYSTEM mentoring workshop held in Pretoria on 17 November 1999)

For the Northern Cape the numbers reflected in Table 4.2 changed, since:

- student numbers decreased from 24 to 22 (see Table 2.5);
- the number of placement schools decreased from 11 to 9;
- the initial 10 mentor teachers changed to 2 mentor teachers per placement school; and
- the 4 supervising lecturers became 3: one mathematics and one chemistry lecturer for evaluating subject-specific lessons, and a co-ordinating lecturer for handling the logistics of the internship and the mentorship programme.

The envisaged professional development programme for SYSTEM college lecturers and mentor teachers (see also Table 2.2) was discussed at a mentoring workshop held in Pretoria on 17 November 1999.

A memorandum (Sesele, 2000a) sent to the five colleges of education gave prominence to the agenda of the workshop and noted the following:

- explaining what the SYSTEM Diploma is all about
- explanation of roles
- team building exercises
- experiences of being mentored
- FDE
- expectations
- commitment.

The memorandum also made specific reference to the SYSTEM budget allocations, stipulating the fees for mentoring workshops and other related expenses. A facsimile (Sesele, 2000b) followed, informing colleges about a mentoring workshop only for college lecturers. Arrangements for a mentoring workshop for the mentor teachers of the placement schools were to follow at a later stage. An attachment to this facsimile referred to the former University of Natal, now the University of KwaZulu-Natal, as the institution selected for offering the mentoring course.

Table 4.3 provides a brief summary of the items discussed at the workshop. One of the resolutions taken at this meeting was that each of the colleges present should hold a "relationship-building workshop" with their mentor teachers.

Table 4.3: Concise summary of the Mentoring Programme Workshop held in Pretoria on 17 November 1999

Item	Details of ensuing discussions
Purpose of workshop	To introduce the mentoring training programme to the college facilitators and to plan and design practical activities for implementation during the internship year.
Main purpose of mentoring	Pick up good teaching. Focus on schools as a source of extra people. Development of mentor teachers and college staff. Students developed in multi-faceted manner, for example, as a classroom manager, an action researcher, distance education exposure, etc.
The mentoring process	Focus on own experience. Relationship between lecturer-mentor-mentee. Reinforcing good practices.
Budget-Business plans of colleges	Waiting for relevant signatures. Provisioning made for: staff development, stipends to students during internship, laboratory equipment for the placement schools.

Table 4.3 . . . continued

Item	Details of ensuing discussions
Staff development and Accreditation	University of Natal had developed a module on mentoring that formed an integral part of a FDE(=ACE), BEd or a MEd - this was the route considered for the college staff. For mentor teachers, the route was a FDE or a BEd that included the mentoring module. Possibilities of sub-contracting to the colleges of education to offer the FDE.
Documentation	Students to have: Diary/journal/portfolio. To do self-assessment. Observation assignments. Recorded lessons(assessed by mentors and Lecturers). By mentor teachers: Assess individual lessons (OBE Approach and CASS). Progress report and register. By lecturers: File all information on students. Assessment. Process evaluation.
Research Project	Action research; Research own teaching / content-specific research. Responsibility of subject lecturer.
Programme for 2000	Ascertain number of lecturer participation. Workshop from 11-18 January 2002 in Pretoria. Enrol for courses at University of Natal. Arrange a workshop with mentor teachers and students. Mentor teachers enrol for FDE or BEd or Post-graduate diploma. Workshop in April. Evaluation in July-assessment session.

4.3.2 The significance of mentorship in teacher-training

Winberg (1999: 3) states that *mentoring is firmly rooted in teaching practice*. The conventional model of becoming a teacher has involved the learning of content knowledge and then embarking on teaching practice for four or five weeks per year spread over two semesters. This spread of field practice remained the same until the completion of the teacher-training course. Nowadays, there is much greater understanding of the complexity of the learning process and the subtleties of the teaching/learning interaction.

SYSTEM introduced a move towards a school-based teacher education model, where pre-service student teachers would spend an extended period (internship) working with mentor teachers at the placement schools. A highly-structured, long-term mentoring relationship (see Table 4.1) was envisaged for the internship period.

During the internship, a mentor teacher had to:

- lend support, guidance and assistance in all teaching practice matters;
- develop and maintain a positive and productive working relationship with the trainee teacher throughout the mentoring process;
- assist the trainee teacher with the implementation of educational theory and principles in the reality of classroom practice;
- assist trainee teachers to design, develop and maintain environments that facilitated learning;
- assist trainee teachers to understand and use effective techniques of classroom management; and
- encourage trainee teachers to continuously improve on their practice through critical self-evaluation.

(Adapted from Winberg, 1999: 4)

In the field of education, a mentor is often associated with the role played by a support teacher, a teacher supervisor, a teacher trainer, an experienced teacher or a teacher co-ordinator. By introducing the notion of the teacher as a mentor and as a trainer, for the sake of clarity, the following differentiation is made between *Mentoring* and *Training* (Winberg, 1999: 2-3):

> *Mentoring* focuses on supporting the trainee teacher during field practice.
>
> *Training* focuses on the broad framework of educational theory and methodology and is mostly institute-based.

For SYSTEM, the internship period provided a foundation for the process of mentoring to develop. During the student's internship, it was expected that the mentor teacher would help the trainee teacher to understand and improve his/her teaching practice and to link practice to the broader theoretical knowledge of classroom pedagogy.

4.3.3 The significance of mentorship to professional development

In this study, the term *professional development* refers to the process of education combined with practice by which men and women are able to equip themselves with knowledge, skills, competence and commitment. This process may be looked upon as developing the capacity to grow intellectually and emotionally and in doing so being able to cope more adequately with the realities of education and educating.

According to SADTU[*14] (2002: 10), the key features of any professional development programme should include:

- mechanisms for ensuring that educators are better able to meet their daily responsibilities regarding learning and teaching;

[*14] South African Democratic Teachers Union.

- developing the capacity of educators to implement education legislation and policies and to deliver the new curriculum effectively;
- enhancing the profession by increasing public confidence in the professional integrity and judgement of teachers; and
- other considerations such as career pathing and life-long learning.

According to the ANC (1994: 264), for SYSTEM: Phase II (teacher-training) to succeed, professional development should occur in the areas of:

- Staff development for colleges of education personnel.
- Curriculum development in the colleges of education.
- Mentor development in the placement schools.
- Development of post-graduate science and mathematics education programmes for both college of education staff and mentor school teachers.
- INSET support for interns.

In teacher education, professional development programmes are targeted either at PRESET[*15] or INSET or both. According to Feiman and Floden (1980: 126), teacher education programmes (both at PRESET and INSET) are supposed to meet the developmental needs of teachers and be evaluated in terms of their contribution to professional development. Fuller (1969: 207), working at the Research and Development Center for Teacher Education at the University of Texas in Austin, identifies three categories of teacher concerns. The first is concerned about *self* (self-survival), the second is concerned about *task* (aspects of teaching) and the third is concerned about *impact* (meeting the needs of the students) [see paragraph 6.2.4: Summary of the results]. Fuller (1969: 226) contends that the highest stages of professional development are those that are able to meet the needs of students (*impact* concerns category). Hence, the significance of a mentorship programme on the professional development of teachers should fall squarely within the impact concerns category of Fuller.

[*15] Pre-Service Education and Training.

According to Winberg (1999: 22), in mentoring the mentor is often called upon to address a variety of different needs. The whole conceptual design of the mentoring process is to meet the needs of the mentee at whatever level it may deem to be advantageous to the process. The primary concern of the mentor should be to recognise the needs of the mentee and to respond appropriately in meeting the challenges. In order to meet such challenges, the significance of mentoring on the professional development of teachers should:

- Facilitate reflective practices for the mentor teacher.
- Assist in establishing collaborative relationships based on trust, collegiality and confidentiality amongst all role players in the mentoring process.
- Promote understanding of the academic, professional and social needs of pre-service student teachers.

4.3.4 The implementation of the mentorship programme for SYSTEM: Northern Cape

The implementation of a mentorship programme for SYSTEM in the Northern Cape was to focus on, *inter alia*:

A mentorship programme that was school-based:

Author's Comment:

(a) No programme was ever instituted for college-based mentoring even though correspondence reflected the intention to train lecturers in a mentoring programme.

(b) It was expected that the college lecturers act as subject mentors especially in the major subjects.

(c) Peer/co-operative learning became pivotal in the absence of any formal mentoring programme at the college.

School selection for the internship placements:

(a) Schools with prior working relationships with the college.
(b) Favoured teaching practice schools.
(c) Placement schools were all senior secondary schools.

Mentor teacher selection:

(a) Two mentor teachers per placement school - one for mathematics and one for science.
(b) Preferably Heads of Departments : Mathematics / Science, if not, then senior or experienced mathematics / science teachers suitably qualified in their discipline.

Student placements:

(a) Students could choose any school (selection conditional to item 2 above).
(b) Switching between schools during internship was not encouraged.

Author's Comment:

In two exceptional cases a group of students were allowed to change their placement schools, due to requests from these students and their respective mentor teachers, based on personal and professional conflicts.

Supervising college lecturers:

(a) Had to make a number of visits per month to the placement schools to observe/evaluate SYSTEM students (teaching) in the classroom, and to deal with other related issues, and provided remedial assistance if necessary.
(b) Had to discuss the observation/evaluation with the student and mentor teacher.

4.4 MENTOR AND MENTEE INTERVIEWS

For SYSTEM, the significance of mentorship for the Phase II programme (teacher-training) was inextricably linked to the professional development of its staff, mentor teachers and the SYSTEM students (ANC, 1994: 264). Students' perceptions of their development under mentorship of professional educators (mentor teachers) during the internship, was elicited through interviews (findings presented in paragraphs 6.3 & 7.3). The focus of the interviews targeted two sets of participants, namely, the mathematics mentor teachers at the placement schools and a group of selected SYSTEM students (interns). The interviews with the mathematics mentor teachers (one mentor per school) were conducted during the period of August to October 2002 at the placement schools. The interviews with the SYSTEM students were conducted during the first week in November 2002 at the College of Education in Kimberley. Audio recordings of the interviews were made. The audio recordings are in the possession of the author.

The nine placement schools, located within the Kimberley educational district, were:

1. Tshireleco Senior Secondary School
2. St. Boniface Catholic School
3. Emang Mmogo Comprehensive School
4. Tlhomelang Senior Secondary School
5. Tetlanyo Senior Secondary School
6. Thabane Senior Secondary School
7. Vuyolwethu Senior Secondary School
8. Pescodia Senior Secondary School
9. Homevale Senior Secondary School.

The purpose of the interviews was:

1. To ascertain the perceptions of what mathematics mentor teachers think their roles and duties should be with regard to mentoring the SYSTEM students.
2. To ascertain the perceptions of SYSTEM students about the nature of their relationships with their mentor teachers, what they gained from the mentoring relationship and about the internship period as a whole.
3. To gain an understanding of the mathematics mentor teachers and SYSTEM student perceptions' about the effectiveness of mentoring, as well as insight into the professional development of the mentor (school teacher) and the mentee (student teacher).
4. To address Research Question 3 on the relevancy of mentorship to SYSTEM Phase II (see paragraph 4.4.3).

4.4.1 Types of interviews used in this study

Three types of interviews were used in this study. The author deemed it best not to limit responses to monosyllabic answers but to encourage respondents to answer in a *carte-blanche* manner. By acknowledging the multitude of contributory factors that may influence the experiences and dispositions of the respondents during the mentoring process, the use of open-ended questions was deemed to be the best.

4.4.1.1 *Structured interviews*

In a structured interview, the interviewer puts a collection of questions from a previously compiled questionnaire, known as the *interview schedule* (see Appendix E), to a respondent face-to-face and records the latter's responses (Welman & Kruger, 1999: 166).

Structured interviews with the mathematics mentor teachers were conducted (see paragraph 4.4.2) at the following schools:

1. Tshireleco Senior Secondary School
2. St. Boniface Catholic School
3. Emang Mmogo Comprehensive School
4. Tlhomelang Senior Secondary School.

4.4.1.2 *Unstructured interviews*

In unstructured interviews the interviewer simply suggests the general theme of discussion and poses further questions as these come up in the spontaneous development of the interaction between interviewer and respondent (Welman & Kruger, 1999: 196).
Unstructured interviews with the mathematics mentor teachers were conducted (see paragraph 4.4.2) at the following schools:

1. Tetlanyo Senior Secondary School
2. Thabane Senior Secondary School
3. Vuyolwethu Senior Secondary School
4. Pescodia Senior Secondary School
5. Homevale Senior Secondary School.

4.4.1.3 *Semi-structured interviews*

In semi-structured interviews, varying degrees of structuredness are possible. Semi-structured interviews are considered when topics are of a sensitive nature. It allows the interviewer to probe or ask for elaboration of incomplete answers.

Interview guides (see Appendix F), as opposed to interview schedules, are used in semi-structured interviews. An interview guide involves a list of topics (not specific questions) which have a bearing on the theme that the interviewer should bring up during the course of the interview. Although all respondents are asked the same questions, the interviewer may adapt the formulation, including the terminology, to fit the background and educational level of the respondents (Welman & Kruger, 1999: 167).

Semi-structured interviews were conducted with the group of SYSTEM students (see paragraph 4.4.2).

4.4.1.4 *Triangulation*

To ensure the internal validity of the interviews, the techniques of triangulation were used (see to Figure 4.1).

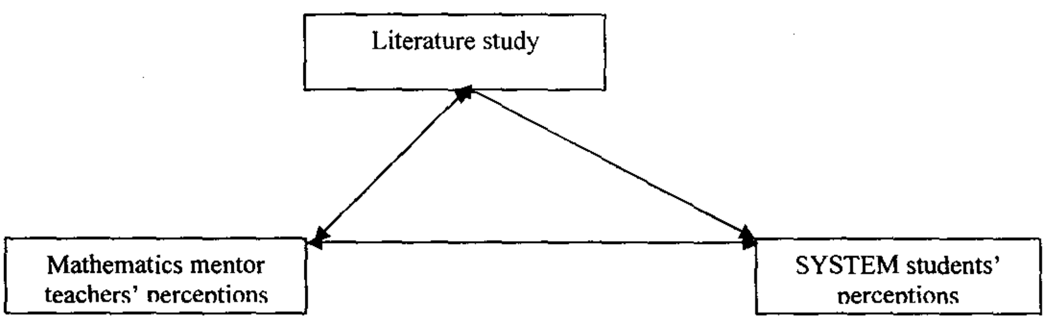


Figure 4.1: Triangulation of perceptions and theory

In this study, the triangulation technique involved looking for common themes (perceptions/expressions/statements) which appeared in the interviews (with SYSTEM students and mathematics mentor teachers) and linking them (in a supportive manner) within a theoretical premise (based on the literature study).

4.4.2 A summary of the conducted interviews

The following statements are a summary of the structured interviews conducted with the mathematics mentor teachers. The interviews took place at the respective placement schools and lasted about 10 minutes with each of the respondents. The questions were taken from a prepared *interview schedule* (Appendix E). The core responses (common and differentiated) are noted below.

What do you think your role and responsibilities were as a maths mentor teacher for the SYSTEM students?

Responses vary from:

"*To first observe how their teaching is, how they act towards the pupils. To give guidance and to allow the person that you are mentoring to learn from you. And as an experienced (person) we must lead by example.*"

to

"*Mentoring is helping student teachers feel confident. My role as a mentor was to assist them (students) in the classroom.*"

to

"*I must see to it that they (students) have planned their lessons and do their duty.*"

to

"*Mentorship to me is a relationship between an experienced educator and a would-be educator. My role as a mentor is more like a facilitator and to help them gain classroom experience.*"

to

"*Mentoring is a new thing to me, especially mentoring prospective teachers. I have received no training or support (in mentoring) from the college. The students were more supportive than the college.*"

When you were observing the SYSTEM students in the classroom, how did they handle class discipline and control?

Responses vary from:

"The male student controls the class better than the female student"

to

"In the initial stages (of their internship), they (students) couldn't control the class...it took a lot of time to understand the learners."

to

"It is quite obvious, from my experience, that they could handle learners well."

In which way did you assist the SYSTEM students with lesson planning and preparation?

Responses vary from:

"I tried to change their way of lesson planning ... try to show them our (school) lesson preparation."

to

"I made certain that when they (students) came for lessons, that the work they must cover is in the syllabus ... also assisted them with their worksheets."

In which way did you assist the SYSTEM students with their teaching style and methodology? -Did they teach using the problem-centred approach?

Responses vary from:

"I could detect that style (problem-centred approach), very free and letting the learners do more of the work and becoming more involved."

to

"In most cases what they (students) did was to teach the traditional way..."

to

"They (students) came with the problem-centred style because you could see that they've got the knowledge of OBE and were applying it a lot of times."

In your opinion how would you compare SYSTEM student teachers with non-SYSTEM student teachers?

Responses vary from:

"They (SYSTEM students) were more familiar with the school ... they were more comfortable in comparison with the others (non-SYSTEM students)."

to

"They were more confident compared to other students."

to

"There is a big difference. The students who come here for a short time (non-SYSTEM students) are more mark-orientated."

Describe the success (advantages) or failures (disadvantages) of the internship period.

Responses vary from:

" I think there are a lot of advantages ... (it) means theories changing into practical situations..."

to

"By observing the student, I saw things (approaches) that were new to me."

to

"The maximum length of teaching practice allowed the students to get to know the educators well, the learners and become more experience with the lessons (content)."

Closing statements on the SYSTEM students and internship / mentorship:

Responses vary from:

"There is more that I could have done (as a mentor)...given guidance by the college, we could have achieved much more..."

to

"I also learned something from them (SYSTEM students)...they were always willing to help...they didn't isolate them from the rest of the staff."

to

" I think this SYSTEM story (project) is a good thing...it was beneficial to the learners and beneficial to the school. "

The following statements are a summary of the unstructured interviews conducted with the mathematics mentor teachers at the placement schools and lasted for about 6 minutes with each of the respondents:

The general theme was: "What is your purpose as a mentor teacher?"

To the question: "What is your purpose as a mentor teacher?" the following responses were elicited:

"Willingness to assist others...to be a role model for students."

to

"To provide leadership and to work with student teachers by guiding them in the classroom and within the context of the school."

to

"To help students in the teaching methodology of a subject...as well as helping them (students) interpret the syllabi..."

to

"To help with classroom management especially class control, which my SYSTEM student seems to have a problem with."

to

"To make the curriculum real to my students."

to

"To show them (students) how the theory they learn at college can be use in the classroom."

to

"To show the students the school's rules and systems, how a school day is organised and what the school expects from student teachers."

to

" Making the student feel one of the staff and welcome in the classroom...also to help develop the student into becoming a good teacher."

to

"Helping a new teacher adjust to the work of teaching...and help the new teacher become part of the school community."

to

"To provide coaching and support to these SYSTEM students..."

The following statements are a summary of the semi-structured interviews conducted with a group of eight SYSTEM students at the College of Education. The interview lasted for about 15 minutes with the group.

The questions were taken from a prepared *interview guide* (Appendix F) and were framed around broad, key questions on mentoring and mentorship.

Reflect on the training provided by the college in preparation for the internship period.

Responses vary from:

"At college we are taught a lot of educational theory and cannot see how this (theory) can be applied at schools...the reality at schools are too real."

to

"*We were told by our lecturers how to do things when we go the schools, but we haven't seen any practical demonstrations...*"

to

"*Too much theory, too little practice for us students.*"

Describe how you felt when you first met your mathematics mentor teacher.

Responses vary from:

" *I remember being very nervous ... I remember the first few days being very frightening...*"

to

"*I was very anxious... I became very tense because of my anxieties of having to be amongst strangers ... and still having to do such a long internship.*"

to

" *I met my mentor in a very relaxed atmosphere ... he was very friendly and very positive of me being at that school...*"

What was the nature of your relationship with your mathematics mentor teacher?

Responses vary from:

"*Very friendly, open and enthusiastic ... she guided me a lot with regard to lesson planning and preparation...*"

to

"*I could tell him anything, he is a nice and trustworthy person.*"

to

"*I think my mathematics mentor felt threatened by me ... he was not sure about OBE and the problem-centred approach ... I also told him of a few mathematics problems he was doing wrong on the board...because of the personal conflict that developed, I have requested to be moved to another (placement) school.*"

<u>What did you gain from this mentoring relationship?</u>

Responses vary from:

"*I became more confident in my teaching abilities ... I developed a good friend(ship)..*"

to

"*I realise that my mentor was interested in my well-being ... he helped me develop personally.*"

to

"*My mentor was a good role model ... I want to become a teacher just like him...was very dedicated towards his learners...*"

<u>Identify points you think you have in common with your mathematics mentor teacher.</u>

Responses vary from:

" *We care about the changes that we can bring about ... have same interests and enthusiasm for mathematics.*"

to

"*I think we are both good people ... I like to help others and have been involved in tutoring matric maths learners.*"

to

"*I like to achieve the goals I set for myself ... so does my mentor teacher.*"

<u>From experience, what changes need to be made to make mentoring operational in schools?</u>

Responses vary from:

"*Recruiting retired teachers to be mentors to new teachers ... tapping into their life-experiences.*"

to

"Providing incentives to teachers so that they do not regard mentoring as extra work."

to

"Bringing teachers, teacher unions, school administrators, cleaning (support) staff, almost everyone on board ... the education department must also play a very important part here."

Who should be involved in evaluating the success of the mentoring programmes at the placement schools?

Responses vary from:

"As students we should do that ... we have knowledge of its workings"

to

"Lecturers, mentors and students."

to

"The SYSTEM Task Team ... since they need to report on what is happening during the internships at the schools as well as in all the other provinces."

4.4.3 A qualitative analysis of the interviews

This analysis of the interviews centred on the broader issues surrounding the internship and mentorship, with the key perceptions of the respondents being summarised. The nature of these interviews holds the possibility of assessing the roles of the interviewees as they reflected on their role as mentors/mentees during the internship period. Interviewing mathematics mentor teachers posed some challenging problems. Although prior arrangements were made for suitable, isolated venues at the placement schools and at a pre-arranged time, one interview had to be done in full view of the learners in the classroom. Another interview took place in a storeroom of a school and an interview was done in a staff-room with other educators present.

The timing of the interviews was important so as to cause minimal disruption to the schools' programmes. Some respondents lacked understanding of the questions posed and provided irrelevant answers. Questions were then rephrased. The author ascribed this to the fact that some of the mentor teachers were first-time interviewees, or they could have simply been intimidated by the questions asked. Inaudible responses posed a challenged in the transcription of these interviews.

In defining their roles as mentors, the mathematics teachers referred to the concerns of the SYSTEM students' needs in receiving classroom support and guidance. The mathematics teachers' perceptions could be triangulated with one of the three concerns categories of Fuller (1969: 207), namely the impact category (see also paragraph 4.3.3). The students, in turn, perceived the assistance provided in lesson planning and preparation as being essential to them, and they were thus task-concerned (Fuller's Task category). Winberg (1999: 4) posits that the role of the mentor teacher is to provide assistance to trainee teachers to design, develop and maintain environments that facilitated learning.

The relationship between the mentor and mentee is best described in the manner in which some mentors viewed themselves as "experienced educators" of classroom practice in providing professional and emotional support to their mentees. The mentors' concerns centred around providing adequate guidance, assisting with lesson planning and preparation, and supervising lesson presentations. Furlong and Maynard (1995:158) state that their study showed that teachers were not only concerned with the intellectual development of their mentees, but also with the moral and emotional development of the students and to inculcate a positive attitude towards teaching. Students, in their reflections, described their mentors as trustworthy and good role models. Further triangulation of these perceptions with theory, is provided by Winberg (1999: 16-23) who states that recognising the needs of a person adapting to a new role and leading by example are challenges that a mentor has to respond to appropriately.

Interpreting student responses to the mentors' dispositions towards them as open and enthusiastic encouragement, one could allude to the fact that students' attitudes and anxieties were positively influenced.

This was evident in the responses during the interviews when students analysed their own performances during the internship. In triangulating these views with theory, Cohen (1995: 29) posits that a mentee would respond to and rely on the observable behaviours of the mentor as the indicator of internal intentions or motives (cf. also Gardiner, 1995: 49).

The advantages of doing an internship instead of teaching practice sessions were summed up by the mentors as an opportunity for students to develop confidence in their teaching abilities. Students viewed the internship as an opportunity to develop by observing the realities of practice at their placement schools. The validity of such views could be triangulated and supported in the contentions expressed by Feiman and Floden (1980: 126), who state that teacher education programmes were supposed to meet the developmental needs of teachers (both INSET and PRESET) and be evaluated in terms of their contribution to professional development.

Reflections from an interview with a group of SYSTEM Diploma students (2002) showed that mentor teachers provided task-related and problem-related assistance and advice. However, some students were of the opinion that the mentor teachers sometimes lack knowledge of progressive teaching methods, such as the problem-centred approach and the OBE methodology.

Based on the qualitative processing of the mathematics mentor teachers' and students' perceptions on mentorship and mentoring, and in light of *Research Question 3*: "How relevant was mentorship to the SYSTEM students during the internship period?", the responses during the interviews were overwhelmingly positive (see paragraph 4.4.2). In further addressing the research question, the perceptions of the mentor teachers revealed how "comfortable" and "confident" some SYSTEM students were during the internship compared to non-SYSTEM students doing teaching practice. Based on these sentiments, one could surmise that the duration of the internship provided an ideal opportunity for the mentoring process to unfold and develop. By mentoring these students, the teachers were in a position to assess the development of the student in terms of classroom management (class discipline and control), lesson management (planning and preparation), teaching style (methodology and presentation) and school management (updating attendance register, extra-mural activities, etc.).

For SYSTEM students, mentorship was the revelation of how "the reality at schools are too real", in context of just being taught educational theory at college. Some of the student responses centred around the development of positive relationships with their mentors ("good friendship", "good role model", 'interested in my well-being"). A crowning achievement for mentorship was the response that 'I became more confident in my teaching abilities".

The perceptions of both mentor teachers and SYSTEM students, in addressing the relevance of mentorship during the internship period, points to the fact that mentoring is a *sine qua non* to the development of students to become professional students. This result attested to an acknowledgement by the mentor as providing professional guidance to the SYSTEM students, with the students in turn acknowledging the relevance of receiving on-site coaching and training from the mentor teachers, especially during the lengthy period of internship.

4.5 CONCLUDING REMARKS

The changing educational environment in the New South Africa provides an impetus to introduce "untried" initiatives that may dramatically improve teaching and learning. One such initiative was embarked upon by SYSTEM. The SYSTEM Diploma framework embodied a field practicum section incorporating a mentoring programme within an internship period. The significance of mentorship to SYSTEM was to guide the SYSTEM students into the teaching profession by using school teachers as mentors. Not only was the mentor teacher responsible for introducing the student teacher to the teaching profession but also to the complexities of the organisational structures of the school.

A mentoring relationship between the mathematics mentor teacher and the SYSTEM students developed over time. The internship period provided the ideal opportunity for such a relationship to firmly establish itself. From the responses during the interviews, it was quite evident that some students had formed a personal relationship with their mentor. Elliot and Calderhead (1995: 48-49), observe that:

> "*In many cases mentoring was seen as a direct function of an extremely personal relationship.*"

The interviews conducted with the mentoring mathematics teachers provided some insight into the nature of their relationships in mentoring students and with the SYSTEM project itself. These mentor teachers accepted the SYSTEM students by sharing their responsibilities for classroom teaching, by sharing ideas and making students aware of materials that were available for instruction. One of the pivotal roles of the mentors was helping the students make the transition from college student to professional educator (albeit uncertificated). It is the contention of the author that mentoring should no longer be seen as an option. Rather it should be viewed as an essential part of the professional development of all the role players (learners, students, educators, administrators, non-academic staff) of any educational institution. Mentoring should be seen as a challenge in invigorating an environment of collaboration and *esprit de corps*. According to Reed (1995: 241), any professional programme in teacher education should be dedicated to the idea of excellence in teaching. Mentoring should be part of such an idea.

CHAPTER 5

METHOD AND PROCEDURE FOR THE EMPIRICAL STUDY ON THE MEASURES OF PERCEPTIONS TOWARDS THE STUDY VARIABLES

5.1 INTRODUCTION

The theoretical premises for Study orientation in mathematics, Mathematics anxiety, Attitude towards mathematics and Achievement in mathematics were discussed in detail in Chapter 3. Interviews with the teachers (mentors) and students (mentees) on their perceptions towards mentoring during the internship period were presented in Chapter 4. The aim of this chapter is to report on the method and procedure used in the measurement of the perceptions of SYSTEM students towards the variables of the study, as well as on the structure of the interviewing process. The premise for the selection of the sub-scales for the study variables was presented in Chapter 3 (see paragraphs 3.2.3, 3.3.3, 3.4.3 & 3.5.3). In the exposition of this chapter, the items (fixed/open) within the sub-scales and the rating scales for the measurable study variables are identified. This chapter concludes by providing a summary of the expositional framework for the empirical study.

5.2 METHOD

5.2.1 Research design

This study used field survey-type techniques. A non-experimental survey was used to collect the data. A comparison of group responses towards Study orientation in mathematics, Mathematics anxiety, Attitude towards mathematics and Achievement in mathematics was explored in an *ex-post facto* design.

Measurements were static (one-off) and no conclusions were made on developments or changes in Study orientations in mathematics, Mathematics anxieties, Attitudes towards mathematics and Achievements in mathematics as is done in longitudinal studies.

5.2.2 Population and sample

The initial student population enrolled for SYSTEM Phase II was 24. The variation in student population numbers was outlined in Table 2.5. The participating population size (N) for this study was 22.

There was a discernible dichotomous sub-group within Phase II, each with different achievement levels in mathematics and physical science. Group 1 (n=10) consisted of cohorts of learners directly from Standard 10 (Grade 12). Group 2 (n=12) came from the initial 1997 intake of students for the Recovery Programme (Phase I) who had achieved very poor matriculation passes in mathematics and physical science. No random sampling was done. The sample for the teacher population consisted of nine mathematics mentor teachers from the schools that were identified for the placements of the SYSTEM students during their internship period. No random sampling was done in the selection of the mentors.

5.2.3 Instruments

A two-fold approach was used to elicit responses from the participating SYSTEM students and mentor teachers, namely the use of questionnaires and interviews (see paragraph 1.3.2.3). The initial setting for the use of instruments in this study was outlined in Chapter 1.

The use of questionnaires:

In this exposition, the focus was on defining the sub-scales and the selection of items within the sub-scales.

5.2.3.1 *Sub-scales and items of the MA-SOM-T*

An adapted and modified *Study Orientation in Mathematics Questionnaire* (=SQ4) for tertiary level (MA-SOM-T) [see Appendix A] was used to measure students' perceptions towards their Study orientation in mathematics (see paragraph 3.2.3.1) within an institutional setting. SQ4 was a 20-item Likert-type questionnaire.

For the measures of S*tudy orientation in mathematics* five sub-scales were considered:

1. Study habits in mathematics

Definition: In defining *Study habits in mathematics* for this research, the focus is on effective study methods and habits, the willingness to do mathematics consistently, and promptness to complete assignments and tasks in mathematics.

Fixed-response items: [Note: SOM1 refers to question 1 in SQ4, etc.]

SOM1: I enjoy preparing for tests and exams in maths.

SOM2: I postpone my maths homework and do something I enjoy more.

SOM6: when doing maths homework, I make careless mistakes.

SOM9: I prepare for tests/exams by working out previous question papers.

2. Peer company

Definition: By defining *Peer company*, the consideration is on the effects of students' study orientation in the presence (or absence) of other students.

Fixed-response items:

SOM3: I like doing maths alone at home.

SOM8: I prefer having a maths mentor to assist me with the tasks in maths.

SOM11: I prefer studying in a group to working alone on maths.

SOM14: I feel intimidated by the maths knowledge of my fellow classmates.

3. Time

Definition: In context of the study variable, the sub-scale *Time*, considers the temporal effects of duration and time spent on learning and study.

Fixed-response items:

SOM5: I will work on a maths problem for hours until I solve it.

SOM15: I work every day to keep my Maths homework up to date.

SOM17: I will always catch up on lost work in maths.

SOM18: I do not enjoy spending too much time in solving problems in maths.

4. Content

Definition: The sub-scale *Content* considers subject-specific preferences in study orientation.

Fixed-response items:

SOM4: I become very anxious when studying for Abstract Linear Algebra.

SOM7: I prefer studying maths to any other subject at college.

SOM19: I enjoy working out Calculus problems.

5. Emotional orientation

Definition: For *Emotional orientation*, the sub-scale considers stimulating (or non-stimulating) affective factors that can possibly affect learning and studying.

Fixed-response items:

SOM10: after working on maths for a while, I cannot concentrate any more.

SOM12: unhappiness or frustration prevents me from working hard in maths.

SOM13: I am happy with my study habits for maths.

SOM16: personal problems are why I cannot do my best in maths.

SOM20: I become sleepy, tired or bored when I start doing maths.

Scoring of SQ4 was done using the SOM scale (Maree, 1996: 1), which is a five-point scoring system linked to the following percentage range:

SOM SCALE

1 = Rarely	0 to 15% of the time
2 = Sometimes	16 to 35% of the time
3 = Frequently	36 to 65% of the time
4 = Generally	66 to 85% of the time
5 = Almost always	86 to 100% of the time

In comparison to the fields of the SOM, as outlined by Maree *et al.* (1997: 7-9) [see also paragraph 3.2.3], attitude and mathematics anxiety were not considered for inclusion in the sub-scales of the MA-SOM-T. In this study, Attitude towards mathematics and Mathematics anxiety were considered within the parameters of what effect they have on the achievement in mathematics, unlike the SOM that considers the effects of attitude and mathematics anxiety on study orientation. The decision to include sub-scales (see paragraph 3.2.3.1), other than those reflected in the HSRCs fields, was based on the consideration that the items (within these sub-scales) have to reflect generic influences on students' learning at tertiary level, as well as aspects of representing generalised approaches. Items relating to specific study strategies (as in the SOM) were avoided and only those items that provided for meaningful feedback were considered for inclusion. Some of the items within the MA-SOM-T sub-scales coincided or overlapped with the items reflected in the SOM.

5.2.3.2 *Sub-scales and items of the MA-MARS*

A 20-item Likert-type questionnaire adapted and modified from the *Mathematics Anxiety Rating Scale* (MARS) of Suinn (1972) was used. The MA-MARS (the modified and adapted MARS) [=SQ3, Appendix B] was used to measure the perceptions of SYSTEM students towards Mathematics anxiety within the constructs of the *institutional learning of mathematics* and the *teaching of mathematics during the internship* (see paragraph 3.3.3.1).

<u>The institutional learning of mathematics</u>

The following sub-scales were included in this construct:

1. <u>Mathematics test anxiety</u>

<u>Definition</u>: For purposes of this study, *Mathematics test anxiety* is associated with anticipating, taking and receiving mathematics tests.

Fixed-response items: [Note: ANX1 refers to question 1 in SQ3, etc.]

ANX1: getting ready to study for a mathematics test.

ANX2: working out a concrete, everyday application of mathematics.

ANX6: waiting for a mathematics test to be returned on which I expect to do well.

ANX11: thinking about a mathematics test five minutes before it begins.

ANX19: thinking about a mathematics test one day in advance.

2. General evaluation anxiety

Definition: *General evaluation anxiety* embraces, *inter alia*, completing of assignments, reading textbooks, preparing for mathematics lessons.

Fixed-response items:

ANX4: starting a new chapter in the mathematics course.

ANX8: thinking about beginning a mathematics assignment.

ANX9: doing a word problem in Calculus.

ANX10: opening a mathematics textbook and seeing a full page of problems.

ANX13: having to explain a mathematics problem on the board to fellow students.

ANX15: being asked to answer a mathematics question by my lecturer.

ANX16: being asked to solve an Abstract Vector Algebra problem.

ANX18: having to work in groups to solve a problem.

ANX20: walking to a mathematics class at college.

The teaching of mathematics during the internship

The following sub-scale was included in this construct:

3. Performance (teaching) anxiety

Definition: *Performance (teaching) anxiety*, in this study, emphasizes the act of being observed by others (learners, educators, etc.) and performing mathematical tasks (teaching) in the classroom.

Fixed-response items:

ANX3: teaching a mathematics lesson at school.

ANX5: someone watches me teach mathematics to learners at a school.

ANX7: observing a teacher at the school teaching a mathematics lesson.

ANX12: being asked to teach an unprepared mathematics lesson.

ANX14: sitting in the classroom and waiting for a lesson evaluation from my lecturer.

ANX17: having to teach according to the features of an Outcomes-Based lesson.

The choice of these three sub-scales was based on the consideration that the items contained within the sub-scales best describe the linkage with the two constructs of this study. In adopting and modifying the MARS questionnaire, several redundant items were deleted, most of which referred to everyday applications of mathematics. A small number of items were also modified to remove explicit reference to the United States' units of measure. According to Bessant (1995: 328), the multi-dimensional nature of anxiety allows for additional or new items to be reflected in the sub-scales, as long as those items indicate a proneness to anxiety in a broad range of situations.

Scoring of SQ3 was done using the following Likert-type scale:

1 = strongly disagree
2 = disagree
3 = agree
4 = strongly agree

This scoring differed from the scoring of the standardised MARS questionnaire, which is a five-point scoring system (see paragraph 3.3.3.1). The scale "neither disagree nor agree" was eliminated from the Likert-type scaling procedure due to the proneness of some respondents to give a neutral answer / middle score.

Respondents who are hesitant to assign ratings tend to score in the centre of the scale, thus committing the so-called error of central tendency. Furthermore, in consultation with the Statistical Consultant Services of the University of Potchefstroom, the author agrees with their contention that numerous studies have shown that respondents who are uncertain on how to score tend to go for the safest score. In most cases it is the middlemost score on a 5-point Likert scale.

According to Nunnally (1978: 604), Likert scales have several advantages over all other methods:

- they are easy to construct;
- are usually highly reliable;
- can be adapted to measure many different things; and
- have produced meaningful results in many studies to date.

5.2.3.3 *Sub-scales and items of the Attitude towards mathematics questionnaire*

The attitude questionnaire (=SQ1) was a 10-item Likert-type questionnaire (see Appendix C & paragraph 3.4.3.1). The questionnaire was used in order to establish a measure of the perceptions of SYSTEM students' towards Attitudes towards mathematics.

The two sub-scales used in the questionnaire were:

1. <u>Attitude towards the learning of mathematics</u>

<u>Definition</u>: The sub-scale *Attitude towards the learning of mathematics* focused on the perceptions of the respondents towards the learning of mathematics within an institutional setting. The perspective in this sub-scale was on the role of the student as a learner of mathematics.

Fixed-response items: [Note: ATT1 refers to question 1 in SQ1, etc.]

ATT1: I have enjoyed learning mathematics at college.

ATT3: Learning mathematics was boring and tedious.

ATT5: Mathematics was too abstract and difficult for me.

ATT7: I was very calm and relax when doing mathematics problems.

ATT9: I preferred learning university mathematics to college mathematics.

2. Attitude towards the teaching of mathematics during the internship

Definition: The sub-scale *Attitude towards the teaching of mathematics during the internship* focused on the perceptions of the respondents towards the teaching of mathematics during field practicum. The perspective in this sub-scale was on the role of the student as a teacher of mathematics.

Fixed-response items:

ATT2: I was not self-motivated to work very hard on my mathematics lessons.

ATT4: My internship made me appreciate the joy of teaching mathematics.

ATT6: My teaching style made it easy for learners to understand mathematics.

ATT8: My mentor mathematics teacher at school was of little assistance to me.

ATT10: I enjoyed working with other mathematics teachers at school.

The two sub-scales were decided upon because of the division in the curriculum structure of SYSTEM Phase II between institutional learning and field practicum.

According to Moodley (1981: 90), there is merit in using an equal number of items in each sub-scale because:

- a balance between the dimensions (sub-scales) is maintained; and
- scores, means and standard deviations may be readily and easily compared.

The Likert-type scale used for scoring the attitude questionnaire was the same as that used for scoring MA-MARS.

5.2.3.4 *Sub-scales and items of the Mathematics achievement questionnaire*

A 10-item open-ended questionnaire was used to elicit the perceptions that SYSTEM students have about their *Achievement in mathematics* (=SQ2) [see Appendix D]. The questionnaire was designed to reflect achievements in both institutional and field settings (see paragraph 3.5.3).

The two component sub-scales of SQ2 were:

1. Achievements in the learning of mathematics

Definition: For purposes of this study, *Achievements in the learning of mathematics* refer to how students view their achievements during the learning of mathematics whilst at college (institute-based).

Open-ended items:

Questions 1: Describe one of the most important achievements you think you have made in your study of mathematics at college.

Questions 2: What special aspects of your mathematics education have prepared you for teaching?

Questions 3: What would you describe as your weakness as a mathematics student?

Questions 4: Explain the role you think your mathematics lecturer played in helping you achieve an understanding of mathematics.

Questions 5: What qualities do you think a mathematics student must possess in order to succeed in mathematics?

2. Achievements in the teaching of mathematics

Definition: For purposes of this study, *Achievements in the teaching of mathematics* refer to how students view their achievements in their teaching abilities during internship (field-based).

Open-ended items:

Questions 6: Describe reasons why you would prefer either a teaching internship period or practice teaching sessions.

Questions 7: What planning and lesson preparation did you have to do in order to achieve your outcomes in a mathematics lesson?

Questions 8: Do you think you were adequately prepared at college to achieve success in the teaching of mathematics lessons at school?

Questions 9: What would you rate as a positive achievement during the teaching of mathematics at school?

Questions 10: In your observation of mathematics lessons, how would you compare your teaching style with that of an experienced mathematics teacher?

The use of interviews

Open-ended interviews were conducted with both sets of respondents, the mathematics mentor teachers and a group of SYSTEM students. The design of the interviews featured three types of approaches:

1. Structured interviews: were conducted at four placement schools with the mentor teachers; an interview scheduled (see Appendix E) was prepared (see also paragraph 4.4.1.1).
2. Unstructured interviews: were conducted at five placement schools with the mentor teachers (see also paragraph 4.4.1.2).
3. Semi-structured interviews: were conducted with a group of SYSTEM students; an interview guide (see Appendix F) was prepared (see also paragraph 4.4.1.3).

To ensure the internal validity of the interviews, the technique of triangulation was used (see paragraph 4.4.1.4).

5.2.4 Statistical techniques

A two-fold approach was used for descriptive data analyses:

1. The use of quantitative techniques:

(a) The Cronbach's Alpha coefficients to measure the internal-consistency reliability.
(b) The Means Procedure per group: item means and standard deviations.
(c) Effect sizes (Cohen's d-values).
(d) The Frequency Procedure per group: item percentages.

2. The use of a qualitative technique:

The technique of triangulation was used to ensure the internal validity of the interviews.

5.3 PROCEDURE

Prior to the commencement of empirical study, all of the 22 SYSTEM students and nine mathematics mentor teachers were invited to participate in the completion of the questionnaires and / or interviews.

A letter (see Appendix P) outlining the purpose of the study, as well as guaranteeing confidentiality, was handed over to the prospective respondents. A brief informative session was held with the students prior to the scoring / completion of the four questionnaires. This was done so as to explain the essence of their (students) contribution as well as the potential value of this research study. The participating students were urged to respond accordingly. Students were asked not to write their names on the questionnaires and were assured that their ratings and responses would be treated confidentially. The questionnaires were coded so as to distinguish between Group 1 and Group 2 responses. The two sub-samples were essential to the study since the results of their scorings / responses were to be compared to detect any significant differences in their responses. These results are discussed in Chapter 6.

For the interview sample, the author limited the participating students to eight, four from Group 1 and four from Group 2. These audio interviews were conducted at the college and the interviews were of the semi-structured type.

Permission to visit the placement schools to conduct interviews with the mathematics mentor teachers was obtained from the Northern Cape provincial education department (see Appendix Q). Interviewing mathematics mentor teachers posed some challenging problems (see paragraph 4.4.3). Prior arrangements were made for venues at the placement schools to conduct these interviews. The interviews were of the structured and unstructured type. Prior to the commencement of these interviews, the mentor teachers were informed about the anonymity and confidentiality of their responses. The interviews with the mathematics mentor teachers were audio-taped.

5.4 SUMMARY

This chapter considered the processes and the parameters of the empirical research. An outline of the method and procedure focused on the population and sample size and the instruments. The measuring instruments (questionnaires and interviews) were drawn up so as to reflect the objectives of this study. The modification and adaptation of standardised questionnaires (SOM & MARS) were done so as to produce instruments for use at tertiary level. Most of the questionnaires (except MA-SOM-T) reflected the two main constructs of this study (see Figure 3.1):

- The learning of mathematics (institute-based).
- The teaching of mathematics (field-based).

Within these two constructs, fixed delineations of sub-scales were made prior to data analyses (in Chapter 6). The selection of the sub-scales was based on the theoretical premises for the study variables presented in Chapter 3 (see paragraphs 3.2, 3.3, 3.4 & 3.5). Items within these sub-scales reflected particular nuances towards the two constructs. Content validity of questionnaires was best reflected in the selection of items within the sub-scales and tested via piloting strategies.

For the interviews, an interview schedule and an interview guide for the different types of interviews were prepared. In contrast to the questionnaires which had fixed-response items (except SQ2), the interviews were prepared using open-ended questions. Internal validity of the interviews was determined through a technique of triangulation.

An exposition of the analyses of the processed data and discussions of the results are presented in Chapter 6.

CHAPTER 6

STATISTICAL PROCESSING AND EXPOSITION OF THE RESULTS

6.1 INTRODUCTION

As with most research designs, the presentation of the scored data (from questionnaires) and recorded data (from interviews) are noted in the exposition of the empirical component of the research. For purposes of this study, the qualitative reporting on the recorded interviews (see paragraphs 4.4.2 & 4.4.3) was presented in Chapter 4 (see also paragraph 6.3). This chapter focuses on the analyses of the data for the independent variables, Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics, from a quantitative perspective. Qualitative reporting of the dependent variable, Achievement in mathematics, is done in conjunction with the physical (academic) achievements of SYSTEM students during college examinations and internship assessments. A summary of the results of each of the analyses is provided. These summaries are collated in a general discussion of the results. This chapter concludes by alluding to the implications of the results for the SYSTEM project.

An expositional outline for this chapter is presented in Figure 6.1 and must be viewed as an extension of Figure 3.1.

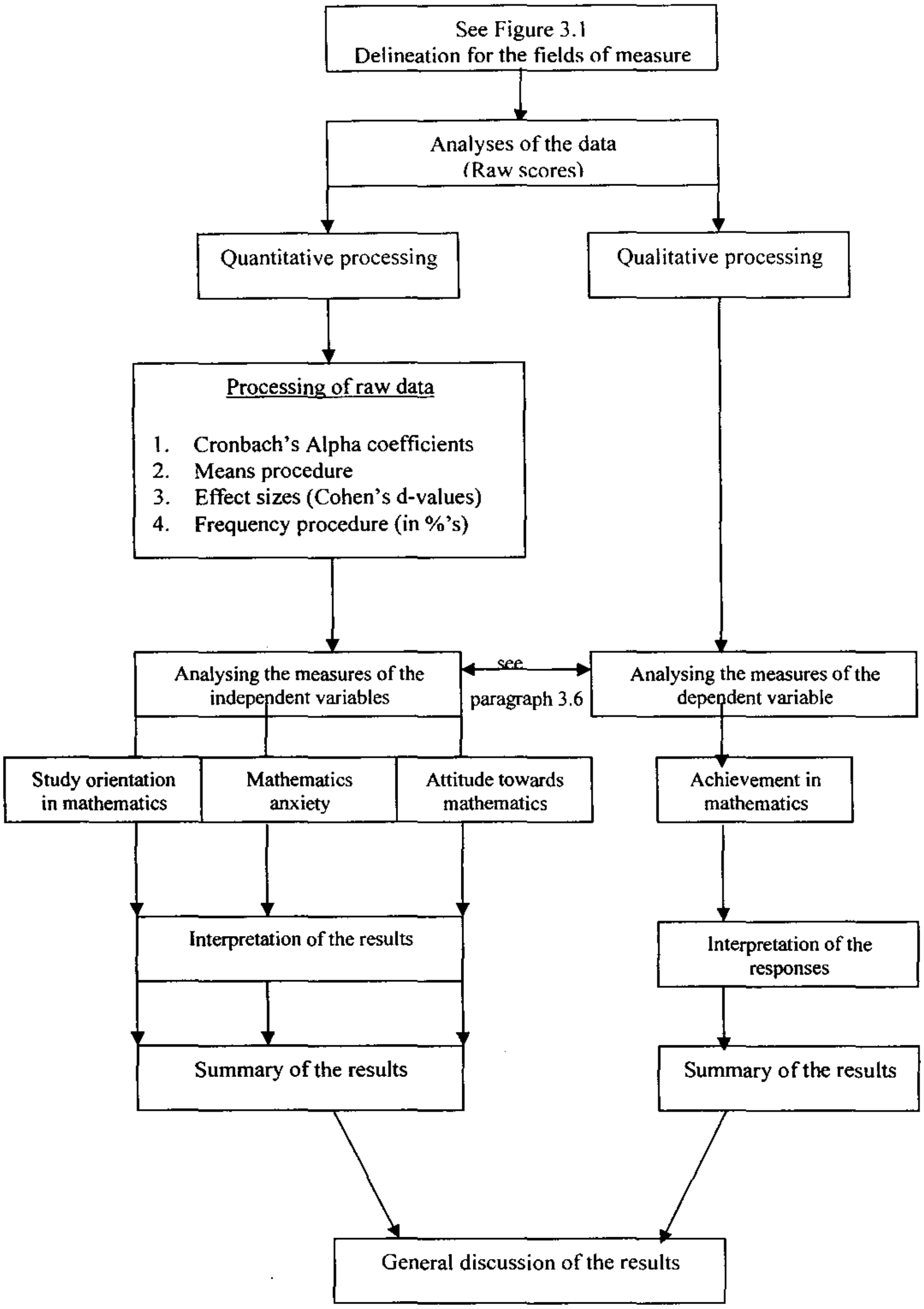


Figure 6.1 Expositional framework for Chapter 6

6.2 ANALYSES OF DATA FROM SCORED QUESTIONNAIRES

The statistical processing of the raw scores was done using the primary Windows-based software programme Statistical Analysis System (SAS) for Windows Release 6.12 (1996). In the computation of the data from the scored questionnaires, some of the sub-scales were excluded from further quantitative analyses because of having too few items. According to Tabachnick and Fidell (1996) [as cited in Hunt *et al.*, 2000: 15], sub-scales with very few items in them are frequently discarded. However, there were several reasons why these types of sub-scales were retained for exploratory and qualitative purposes in this study. Theoretically, the emergence of most of these sub-scales was based on prior research (see Maree *et al.*, 1997: 7-9; Rounds & Hendel, 1980: 14; Resnick *et al.*, 1982: 39; Aiken, 1979: 229; Moodley, 1981: 90), with some of these sub-scales reporting a high test-retest and internal consistency reliability. Furthermore, content validity of the questionnaires was undertaken through limited student participation (sample was drawn from non-SYSTEM pre-services student teachers) to validate the fixed-response items. Any anomalies were discussed with the students and the outcomes of the discussion were used to make modifications to the selected fixed-item statements of the questionnaires. Tabachnick and Fidell (1996) support the retention of inadequate sub-scales for exploratory purposes (qualitative reporting), as well as for further development and testing.

Processing of the data

The data from the questionnaires were statistically processed for:

Reliability measures for the sub-scales

The Cronbach's alpha coefficients were used to assess the internal-consistency reliability of the sub-scales. Sub-scales with Cronbach's Alpha values of less than 0,5 were discarded from further statistical analysis in this study because of their unreliability (see also Nunnally, 1978: 295).

Means procedure

The Means procedure focuses on the means (μ) and standard deviations (σ) for the scored items in the sub-scales. The mean is the most commonly used measure of central tendency. The standard deviation measures how the values fluctuate about the mean. The smaller the value for the standard deviation, the more concentrated or homogeneous the data are (Berenson & Levine, 1996: 106-123).

Effect sizes as a measure of practical significance

Cohen's criterion focuses on the Effect Sizes (ES) of differences between Group 1 and Group 2, that is, whether differences in responses between the two groups were of practical significance. The Effect Size (ES) refers to the degree to which the phenomenon under study is manifested (Cohen, 1988: 10). The ES in the sample can be used for *significance testing* by computing the ES Index-*d* (Cohen's d-value).

Cohen's d-value is the measure of the standardised differences between the means of two groups (see also Steyn, 2000: 1-3). The formula:

$$\mathrm{d} = \left| \frac{\mu_1 - \mu_2}{\sigma} \right| \qquad \text{(Cohen, 1988: 20)}$$

allows for the modulus computation of such d-values.

[In the formula, the notations μ_1 and μ_2 represent the means for the two groups, and σ represents the larger of the two standard deviations for the groups.]

Cohen (1988: 25-27) recommends the following conventional frame of reference (modified to include range values) for the ES Index:

- $d < 0,2$: insignificant differences
- $0,2 \leq d < 0,5$: differences with small effect
- $0,5 \leq d < 0,8$: differences with medium effect
- $d \geq 0,8$: differences of large effect and of practical significance.

Frequency procedure

The sub-scales excluded from quantitative analyses, for reasons outlined earlier in this paragraph, have been included as part of the qualitative reporting done by using measures of frequencies. The Frequency procedure focuses on the percentages (%) computed for the scored items in the sub-scales for each of the groups.

6.2.1 Analysing the perceptions towards Study orientation in mathematics

The MA-SOM-T questionnaire was designed using the following sub-scales (see paragraph 5.2.3.1):

- Study habits in mathematics
- Peer Company
- Time
- Content
- Emotional orientation.

Interpretation of the results

The coding of the SOM items in terms of bi-polarity (+/-) proved problematic for statistical computation through the introduction of polarised sub-scales. The sub-scales *Study habits in mathematics* and *Content* were excluded during quantitative processing because of having too few items of the same polarity (+ or -) in the sub-scale or having too few items with the same number of opposite polarities. These sub-scales were nevertheless retained for qualitative purposes. The computed mean values for the negatively-loaded items (SOM10, SOM12, SOM16, SOM18 and SOM20) were subsequently inverted (with respect to the five-point SOM scale) [see Table 6.2]. The retention of sub-scales and the inversion of means were done on the advice of the Statistical Consultation Services of the University of Potchefstroom.

Reliability measures for the MA-SOM-T sub-scales

Computation of the Cronbach's Alpha coefficient indicated that the sub-scale *Peer company* had insufficient internal-consistency (< 0,5) and was thus unreliable. This sub-scale was excluded from further quantitative processing. The sub-scales *Time* and *Emotional orientation* had moderate to strong alpha coefficient readings respectively (≥ 0,5), indicating sufficient internal-consistency reliability of the sub-scales (see Table 6.1).

Table 6.1: Cronbach's alpha coefficients for the MA-SOM-T sub-scales

Sub-scale	**Cronbach's Alpha coefficient**
Peer company	0,113
Time	0,500
Emotional orientation	0,788

Means procedure

The means and standard deviations had been computed for the items within the sub-scales listed in Table 6.2. Mean values equivalent to 3 indicated that an average number of respondents (from the study population N = 22) frequently agreed with the sentiments expressed by the item statements. In terms of the SOM scale (see paragraph 5.2.3.1), this is equivalent to saying that the respondents agreed 36% to 65% of the time. The SOM items of the sub-scales *Time* and *Emotional orientation* had mean values equivalent to 3 (except SOM12 & SOM18) indicating a tendency for the middlemost score on the SOM scale.

Table 6.2: Means and Standard deviations for the MA-SOM-T items of the Time and Emotional orientation sub-scales

Sub-scale	Study population (N)	Sub-scale Item	Mean	Standard deviation
Time	22	SOM5	2,955	1,290
		SOM15	3,000	0,976
		SOM17	3,455	1,143
		SOM18	2,091	1,203
Emotional orientation	22	SOM10	3,106	1,243
		SOM12	2,421	1,170
		SOM13	2,909	1,260
		SOM16	2,684	1,204
		SOM20	3,053	1,393

[Note: SOM items not reflected in Table 6.2 had been excluded for reasons listed in this paragraph.]

Effect size measures for the MA-SOM-T sub-scales

Computations of Cohen's d-values for the sub-scales *Time* (d = 0,13) and *Emotional orientation* (d = 0,07) revealed insignificant differences between Group 1 and Group 2 responses. Cohen's d-value for *Peer company* was not computed due to the weak reliability of the sub-scale. The values in Table 6.3 were used to compute the d-values.

Table 6.3: The Means procedure per group for the sub-scales Time and Emotional orientation

Group	Sample size	Sub-scale	Mean	Standard deviation
Group 1	10	Time	3,067	0,979
		Emotional orientation	2,667	1,021
Group 2	12	Time	3,194	0,674
		Emotional orientation	2,736	0,970

Frequency procedure

Notwithstanding the exclusions from further quantitative (statistical) processing of some of the sub-scales mentioned earlier, for exploratory purposes the following qualitative report (in relation to the SOM scale) is presented for all of the SOM items (see also Appendix S):

Study habits in mathematics sub-scale:

SOM1: "I enjoy preparing for tests and exams in maths."
20% of Group 1 respondents sometimes agreed with this item statement compared to 58% from Group 2.

SOM2: "I postpone my maths homework and do something I enjoy more."
30% of Group 1 respondents rarely agreed with this item statement compared to 8% from Group 2.

SOM6: "when doing maths homework, I make careless mistakes."
30% of Group 1 respondents agreed 16% to 35% of the time with this item statement compared to 8% of the respondents from Group 2.

SOM9: "I prepare for tests/exams by working out previous question papers."
10% of Group 1 respondents agreed 36% to 65% of the time with this item statement compared to 50% of respondents from Group 2.

Peer company sub-scale:

SOM3: "I like doing maths alone at home."
50% of both Group 1 and Group 2 respondents generally agreed with this item statement.

SOM8: "I prefer having a maths mentor to assist me with the tasks in maths."
40% of Group 1 respondents agreed 66% to 85% of the time with this item statement compared to 25% of respondents from Group 2.

SOM11: "I prefer studying in a group to working alone on maths."
None of Group 1 respondents sometimes agreed with this item statement compared to 17% from Group 2.

SOM14: "I feel intimidated by the maths knowledge of my fellow classmates."
20% of Group 1 respondents almost always agreed with this item statement compared to 25% from Group 2.

Time sub-scale:

SOM5: "I will work on a maths problem for hours until I can solve it."
10% of Group 1 respondents almost always agreed with this item statement compared to 26% from Group 2.

SOM15: "I work every day to keep my maths homework up to date."
20% of Group 1 respondents frequently agreed with this item statement compared to 50% from Group 2.

SOM17: "I will always catch up on lost work in maths."
None of Group 1 and Group 2 respondents agreed 0% to 15% of the time with this item statement.

SOM18: "I do not enjoy spending too much time in solving problems in maths."
30% of Group 1 respondents agreed 36% to 65% of the time with this item statement compared to 25% of respondents from Group 2.

Content sub-scale:

SOM4: "I become very anxious when studying for Abstract Linear Algebra."
30% of Group 1 respondents frequently agreed with this item statement compared to 17% from Group 2.

SOM7: "I prefer studying maths to any other subject at college."
40% of Group 1 respondents agreed 86% to 100% of the times with this item statement compared to 17% of the respondents from Group 2.

SOM19: "I enjoy working out Calculus problems."
20% of Group 1 respondents agreed 86% to 100% of the time with this item statement compared to 17% of respondents from Group 2.

Emotional orientation sub-scale:

SOM10: "after working on maths for a while, I cannot concentrate any more."
56% of Group 1 respondents agreed 0% to 15% of the time with this item statement compared to 46% of respondents from Group 2.

SOM12: "unhappiness or frustration prevents me from working hard in maths."
10% of Group 1 respondents generally agreed with this item statement compared to none from Group 2.

SOM13: "I am happy with my study habits for maths."
30% of Group 1 respondents rarely agreed with this item statement compared to 8% from Group 2.

SOM16: "personal problems are why I cannot do my best in maths."
50% of Group 1 respondents agreed 16% to 35% of the time with this item statement compared to 9% of respondents from Group 2.

SOM20: "I become sleepy, tired or bored when I start doing maths."
20% of Group 1 respondents agreed 66% to 85% of the time with this item statement compared to 17% of respondents from Group 2.

A synopsis of the general trends in the responses of the dichotomous groups revealed convergent scoring (within a small percentage range) for SOM10, SOM14, SOM17, SOM18, SOM19 and SOM20. This pattern could be interpreted as indicative of some degree of homogeneity between group responses. For SOM3, 50% of respondents from both groups generally agreed with the sentiment of preferring to work on their mathematics alone at home. No extreme divergent scores (of a large percentage range) was noted in the percentages of the other SOM items.

Summary of the results

In analysing the perceptions of SYSTEM students (N = 22) towards the independent variable Study orientation in mathematics, five sub-scales were used. Two of the sub-scales, *Study habits in mathematics* and *Content*, were excluded through having too few polarised items for quantitative processing. Computation of alpha coefficients revealed that the sub-scale *Peer company* was statistically unreliable (alpha coefficient = 0,113), leaving *Time* and *Emotional orientation* as the only two sub-scales left for measuring SYSTEM students' perceptions towards Study orientation in mathematics.

The frequency procedure provided the qualitative reporting on a selection of an array of group responses towards individual items, revealing some degree of homogeneity (within a small percentage range) between group responses. Table 6.3 revealed that the mean values for the two sub-scales (equivalent to 3) indicated that both groups frequently agreed (equivalent to a middle/neutral valued response as interpreted on the five-point SOM scale) with the sentiments of the items contained within these sub-scales. The small standard deviations (in relation to the span of the SOM scale) are indicative of homogeneous scoring amongst the average number of respondents. The differences in the means of the dichotomous groups were measured by the ES values. ES measures revealed insignificant differences between Group 1 and Group 2 responses (both with d-values < 0,2) towards the sub-scales *Time* and *Emotional orientation.* Interpretation of this result showed differences of insignificant effect in group 1 and 2 responses for the temporal effects of duration and time spent on learning and study (*Time* sub-scale) [see paragraph 5.2.3.1]. Similarly, differences of insignificant effect in group 1 and 2 responses were noted for the affective factors that could possibly affect learning and studying (*Emotional orientation* sub-scale) [see paragraph 5.2.3.1]. Consequently, the differences between group responses towards the study variable Study orientation in mathematics were thus not of practical significance.

6.2.2 Analysing the perceptions towards Mathematics anxiety

Three sub-scales were used in the MA-MARS (see Appendix B & paragraph 3.3.3.1) questionnaire:

- Sub-scale: Mathematics test anxiety
- Sub-scale: Performance (teaching) anxiety
- Sub-scale: General evaluation anxiety.

Interpretation of the results

The following quantitative analyses of the scored MA-MARS questionnaires are presented:

Reliability measures for the MAR-MARS sub-scales

Cronbach's Alpha coefficients were computed to determine the reliability of the three mathematics anxiety sub-scales. The alpha value for the sub-scale *General evaluation anxiety* was not possible to compute. The internal-consistency factor was too unstable to be computed since the sub-scale had too many anxiety items (nine) measured against a small study population (N = 22). This sub-scale was excluded from further quantitative analyses based on the advice from the Statistical Consultation Services. Alpha coefficients were found to be at acceptable values (> 0,5) for the remaining two sub-scales (see Table 6.4), indicating a measure of sufficient internal-consistency reliability.

Table 6.4: Cronbach's alpha coefficients for the MA-MARS sub-scales

Sub-scale	Cronbach's Alpha coefficients
Mathematics test anxiety	0,677
Performance anxiety	0,631

Means procedure

The means and standard deviations for the anxiety items of the sub-scales *Mathematics test anxiety* and *Performance anxiety* are listed in Table 6.5. Interpretation of the mean scores was done in conjunction with the four-point anxiety scale:

1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree.

Two types of rubrics were used in this study, namely a five-point SOM scale and a four-point anxiety (and attitude) scale. An average of 3 on the five-point scale would indicate a middle/neutral response whereas on the four-point scale such a value would indicate a strong tendency towards the 4-side of the scale.

Mean scores equivalent to 3 indicated that an average number of respondents (from the study population N = 22) agreed with the sentiments expressed in the item statements (in terms of the anxiety scale). Anxiety items ANX1, ANX3, ANX5, ANX11, ANX12 and ANX14 all had mean scores equivalent to 3. Mean scores equivalent to 2 showed disagreements with item statements. Anxiety items ANX2, ANX6, ANX7, ANX17 and ANX19 had mean scores equivalent to 2. The small standard deviations (in relation to the span of the anxiety scale) are indicative of homogeneous scoring amongst the average number of respondents.

Table 6.5: Means and Standard deviations for the MA-MARS items of the Mathematics test anxiety and Performance anxiety sub-scales

Sub-scale	Study population	Sub-scale item	Mean	Standard Deviation
Mathematics test anxiety	22	ANX1	3,000	0,976
		ANX2	2,136	0,889
		ANX6	2,136	0,990
		ANX11	2,727	0,827
		ANX19	2,000	0,690
Performance anxiety	22	ANX3	2,864	0,941
		ANX5	3,136	0,889
		ANX7	1,955	0,785
		ANX12	3,364	0,902
		ANX14	2,591	0,959
		ANX17	2,409	0,854

Effect size measures for the MAR-MARS sub-scales

Computations of the Cohen's d-values for *Mathematics test anxiety* and *Performance anxiety* reported both sub-scales having d-values = 0,2. The ES measures for both the groups showed differences in responses of small effect in the scoring of the two sub-scales. The values in Table 6.6 were used to calculate the d-values.

Table 6.6: The Means procedure per group for the sub-scales Mathematics test anxiety and Performance anxiety

Group	Sample size	Sub-scale	Mean	Standard deviation
Group 1	10	Mathematics test anxiety	2,340	0,490
		Performance anxiety	2,767	0,504
Group 2	12	Mathematics test anxiety	2,450	0,667
		Performance anxiety	2,681	0,566

Frequency procedure

Items from the sub-scale *General evaluation anxiety* were also included for exploratory purposes in the following qualitative report (see also Appendix T):

Mathematics test anxiety:

ANX1: "getting ready to study for a mathematics test"
10% of Group 1 respondents strongly disagreed with this item statement compared to 8% from Group 2.

ANX2: "working out a concrete, everyday application of mathematics"
30% of Group 1 respondents disagreed with this item statement compared to 42% from Group 2.

ANX6: " waiting for a mathematics test to be returned on which I expect to do well"
10% of Group 1 respondents agreed with this item statement compared to 17% from Group 2.

ANX11: "thinking about a mathematics test five minutes before it begins"

40% of Group 1 respondents agreed with this item statement compared to 67% from Group 2.

ANX19: "thinking about a mathematics test one day in advance"

10% of Group 1 respondents strongly disagreed with this item statement compared to 33% from Group 2.

General evaluation anxiety:

ANX4: "starting a new chapter in the mathematics course"

11% of Group 1 respondents strongly agreed with this item statement compared to none from Group 2.

ANX8: "thinking about doing a mathematics assignment"

30% of Group 1 respondents strongly disagreed with this item statement compared to 42% from Group 2.

ANX9: "doing a word problem in calculus"

10% of Group 1 respondents strongly disagreed with this item statement compared to none from Group 2.

ANX10: "opening a mathematics textbook and seeing a full page of problems"

An equal number of respondents from Group 1 and Group 2 disagreed with this item statement.

ANX13: "having to explain a mathematics problem on the board to fellow students"

40% of Group 1 respondents disagreed with this item statement compared to 33% from Group 2.

<u>ANX15</u>: "being asked to answer a mathematics question by my lecturer"
10% of Group 1 respondents strongly agreed with this item statement compared to 25% from Group 2.

<u>ANX16</u>: "being asked to solve an Abstract Vector Algebra problem"
None of the respondents from both groups strongly disagreed with this item statement.

<u>ANX18</u>: "having to work in groups to solve a problem"
None of the respondents from both groups strongly agreed with this item statement.

<u>ANX20</u>: "walking to a mathematics class at college"
30% of Group 1 respondents disagreed with this item statement compared to 33% from Group 2.

<u>Performance (teaching) anxiety:</u>

<u>ANX3</u>: "teaching a mathematics lesson at school"
40% of Group 1 respondents agreed with this item statement compared to 42% from Group 2.

<u>ANX5</u>: "someone watches me teach mathematics to learners at a school"
30% of Group 1 respondents strongly agreed with this item statement compared to 42% from Group 2.

<u>ANX7</u>: "observing a teacher at the school teaching a mathematics lesson"
50% of Group 1 respondents disagreed with this item statement compared to 33% from Group 2.

<u>ANX12</u>: "being asked to teach an unprepared mathematics lesson"
40% of Group 1 respondents strongly agreed with this item statement compared to 76% from Group 2.

ANX14: "sitting in a classroom and waiting for a lesson evaluation from my lecturer"
50% of Group 1 respondents strongly disagreed with this item statement compared to 8% from Group 2.

ANX17: "having to teach according to the features of an Outcomes-Based lesson"
60% of Group 1 respondents agreed with this item statement compared to 42% from Group 2.

A synopsis of the general trends in the responses from the dichotomous groups revealed convergent scoring (within a small percentage range) from both groups for ANX1, ANX2, ANX3, ANX5, ANX6, ANX13, ANX16, ANX18 and ANX20. These scores (percentage-wise) could be indicative of some degree of homogeneity between group responses. For ANX10, 50% of respondents from both groups disagreed that they experienced some form of anxiety when opening a mathematics textbook and seeing a full page of problems. A divergent score (within a large percentage range) was noted for ANX14 (50% of Group 1 and 8% of Group 2 respondents scored this item).

Summary of the results

The perceptions of SYSTEM students towards the independent variable Mathematics anxiety were measured using the two sub-scales *Mathematics test anxiety* and *Performance anxiety*. Cronbach's alpha coefficients reported sufficient internal-consistency reliability for these two sub-scales (alpha coefficients $\geq$ 0,5). The third sub-scale *General evaluation anxiety* was excluded from quantitative analyses due to the instability of the internal-consistency factor.

The frequency procedure provided the qualitative reporting on a selection of an array of group responses towards individual items (percentage-wise), revealing some degree of homogeneous scoring (within a small percentage range) between the groups.

The set of items ANX1, ANX3, ANX5, ANX11, ANX12 and ANX14 (from the two reliable sub-scales) had relatively high mean scores (in terms of the anxiety scale) [see Table 6.5]. Their corresponding standard deviation values were small (in relation to the span of the anxiety scale), revealing some uniformity in the average number of responses. The set of mean scores for ANX2, ANX6, ANX7, ANX17 and ANX19 was equivalent to 2 on the anxiety scale. The commonality in the item mean scores for the two sets of anxiety items above, revealed no extreme mean scores on the anxiety scale. Table 6.6 revealed that the mean values for the two sub-scales vary within the disagreement and agreement range (as interpreted on the anxiety scale). This phenomenon was reflected in the means of the items within these two sub-scales (see Table 6.5). The differences in the means of the dichotomous groups were measured by the ES values. ES measures for the two sub-scales *Mathematics test anxiety* and *Performance anxiety* reported Cohen's d-values equal to 0,2, revealing differences between group responses of small effect. For *Mathematics test anxiety*, differences between group 1 and group 2 responses were of small effect towards the anticipation, taking and receiving of mathematics tests (within an institutional setting) [see paragraph 5.2.3.2]. For *Performance anxiety*, the differences in the responses of the two groups of SYSTEM students (during field practicum) towards being observed by others (learners, educators, etc.) and performing mathematical tasks (teaching) in the classroom were of small effect (see paragraph 5.2.3.2). Consequently, the differences between group perceptions towards study variable Mathematics anxiety were slightly noticeable but not of practical significance.

6.2.3 Analysing the perceptions of Attitude towards mathematics

Two sub-scales were used to measure the perceptions of SYSTEM students' attitude towards mathematics (see Appendix C & paragraph 3.4.3.1).

The sub-scales were:

- Attitude towards the learning of mathematics
- Attitude towards the teaching of mathematics

The settings for the students' perceptions of their attitudes towards mathematics were institutional-based (the College of Education) for the learning of mathematics, and field-based (the placement schools) for the teaching of mathematics.

Interpretation of the results

Quantitative processing of the measures of the attitudinal items for the independent variable *Attitude towards mathematics* was done.

Reliability measures for the attitudinal sub-scales

As measured by Cronbach's Alpha coefficients (see Table 6.7), the internal–consistency reliability for the sub-scale A*ttitude towards the learning of mathematics* was 0,797 indicating a highly stable and reliable sub-scale. The sub-scale A*ttitude towards the teaching of mathematics* during internship had a measure of the alpha coefficient of less than 0,5 and was thus excluded from further quantitative analysis because of insufficient internal-consistency. This sub-scale was retained for the purpose of qualitative analyses.

Table 6.7: Cronbach's alpha coefficients for the Attitude sub-scales

Sub-scale	Cronbach's Alpha coefficient
Attitude towards the learning of mathematics	0,797
Attitude towards the teaching of mathematics during internship	0,402

Means procedure

The means and standard deviations were computed for the attitudinal items of the sub-scale *Attitude towards the learning of mathematics* and presented in Table 6.8. The rating scale for measures of the attitudinal items was the same as that used for the anxiety items. ATT1, ATT3, ATT7 and ATT9 had mean scores equivalent to 3. The relatively high mean scores showed that the average number of respondents (from the study population N = 22) agreed in having some degree of predisposition towards the sentiments expressed in the attitudinal items. For ATT5, μ = 2,409, indicating that the average number of respondents from the sample disagreed with the item statement.

Table 6.8: Means and Standard deviations for the attitudinal items of the Attitude towards the learning of mathematics sub-scale

Sub-scale	Study population (N)	Sub-scale item	Mean	Standard deviation
Attitude towards the learning of mathematics	22	ATT1	3,227	0,685
		ATT3	3,000	1,024
		ATT5	2,409	1,221
		ATT7	2,591	0,908
		ATT9	2,818	1,181

Effect size measure for the attitudinal sub-scales

The computed Cohen's d-value for the sub-scale *Attitude towards the learning of mathematics* was d = 0.6. The ES measure for this sub-scale revealed group differences of medium effect. The values in Table 6.9 were used to determine the d-value.

Table 6.9: The Means procedure per group for the sub-scale Attitude towards the learning of mathematics

Group	Sample size (n)	Mean	Standard deviation
Group 1	10	3,040	0,729
Group 2	12	2,617	0,760

Frequency procedure

Qualitative reporting of all attitudinal items is presented below (see also Appendix U):

Attitude towards the learning of mathematics:

ATT1: "I have enjoyed learning mathematics at college"
50% of Group 1 respondents strongly agreed with this item statement compared to 25% from Group 2.

ATT3: "Learning mathematics was boring and tedious"
20% of Group 1 respondents disagreed with this item statement compared to 25% from Group 2.

ATT5: "Mathematics was too abstract and difficult for me"

30% of Group 1 respondents strongly disagreed with this item statement compared to 42% from Group 2.

ATT7: "I was very calm and relaxed when doing mathematics problems"

10% of Group 1 respondents disagreed with this item statement compared to 42% from Group 2.

ATT9: "I preferred learning university mathematics to college mathematics"

20% of Group 1 respondents disagreed with this item statement compared to 25% from Group 2.

Attitude towards the teaching of mathematics during internship:

ATT2: "I was not self-motivated to work very hard on my mathematics lessons"

30% of Group 1 respondents agreed with this item statement compared to 33% from Group 2.

ATT4: "My internship made me appreciate the joy of teaching mathematics"

None of the respondents from both groups strongly disagreed with this item statement.

ATT6: "My teaching style made it easy for learners to understand mathematics"

60% of Group 1 respondents agreed with this item statement compared to 58% from Group 2.

ATT8: "My mentor mathematics teacher at school was of little assistance to me"

10% of Group 1 respondents strongly agreed with this item statement compared to 42% from Group 2.

ATT10: "I enjoyed working with other mathematics teachers at school"

70% of Group 1 respondents agreed with this item statement compared to 50% from Group 2.

A synopsis of the general trends in the responses of the dichotomous groups revealed convergent scoring (within a small percentage range) from both groups for ATT2, ATT3, ATT4, ATT6 and ATT9. These scores (percentage-wise) could be interpreted as indicative of some degree of homogeneity between group responses. Divergent scores (within a large percentage range) were noted for ATT7 and ATT8 (10% of Group 1 and 42% of Group 2 respondents scored these two items).

Summary of the results

The predisposition of SYSTEM students towards the teaching and learning of mathematics was measured using both quantitative and qualitative processing (frequency procedure). Measurements were done at both the sub-scale and item levels. At the sub-scale level, the Cronbach's Alpha coefficient for *Attitude towards the learning of mathematics* was 0,797, showing a high internal-consistency reliability. The alpha coefficient for *Attitude towards the teaching of mathematics* was less than 0,5 (see Table 6.7) and the sub-scale was thus excluded from further quantitative analyses.

The relatively high mean scores for ATT1, ATT3, ATT7 and ATT9 attest to the fact that the average number of respondents (from the study population N = 22) agreed (in relation to the attitude scale) in having some degree of predisposition towards the item statements. Individualised item scoring (percentage-wise) was reported on using the frequency procedure which revealed some degree of homogeneous scoring (within a small percentage range) from the two groups. The differences in the means of the dichotomous groups were measured by the ES values. ES computation at the sub-scale level reported that *Attitude towards the learning of mathematics* had a d-value = 0,6, revealing differences between group perceptions of medium effect. Consequently, the differences in the perceptions between the two groups for the study variable Attitude towards mathematics were thus noticeable but not of practical significance.

6.2.4 Analysing the perceptions of Achievement in mathematics

The two sub-scales used for the qualitative analyses of the achievement questionnaire (see Appendix D) were:

- Achievements in the learning of mathematics
- Achievements in the teaching of mathematics

Settings for the measurements of the dependent variable, Achievement in mathematics, were institutional (college-based) and in the field (school-based).

Interpretation of the responses

The perceptions of the SYSTEM students about their achievements in mathematics were elicited using *open-ended* questions. No discernible group-differentiated responses were done as was the case for the quantitative analyses of the independent variables. The following qualitative report of the core (highlighting only the key phrases) responses is listed below:

Achievements in the learning of mathematics

Responses to the questions within this sub-scale were very positive in nature from both groups, varying in uniformity as noted below:

To question 1: "Describe one of the most important achievements you think you have made in your study of mathematics at the college", responses varied from:

"(ability to do) *problem-solving*" ... "*change my ways of thinking about mathematics*" ... "*able to teach mathematics*" ... "(have) *a positive attitude*" ... "*acquire confidence in doing mathematics*".

To question 2: "What special aspects of your mathematics education have prepared you for teaching", the responses were:
"*positive attitude*" ... "*hard work and being mo*tivated" ... "*different methodologies*" ... "*motivation from peers*" ... "*learner-teacher relationship*".

Question 3: "What would you describe as your weakness as a mathematics student" elicited the following statements:
"*not enough perseverance*" ... "*interpreting maths problems*" ... "*never experienced* (any) *weaknesses thus far*" ... "*not practising my mathematics*" ... "*ability to give up easily*" ... "*I am always lazy*".

To question 4: "Explain the role you think your mathematics lecturer played in helping you achieve an understanding of mathematics", positive and uniformed responses were noted from both groups, such as:
"*easily approachable*" ... "*inspired me a lot*" ... "*my confidence was built up*" ... "*supportive of my efforts*" ... "*motivational*".

To question 5: "What qualities do you think a mathematics student must possess in order to succeed in mathematics", responses varied from:
"*self-discipline*" ... "(be) *hard-working*" ... "*be goal-oriented*" ... "*good maths background*" ... "*work and concentrate hard*".

Achievements in the teaching of mathematics

Responses to the questions within this sub-scale were very constructive from both groups, and varied as follows:

For question 6: "Describe reasons why you would prefer either a teaching internship period or practice teaching sessions", all the respondents indicated their preference for a teaching internship. Reasons varied from:
"*gain*(ing) *more experience*" ... "*help*(s) *me practice more*" ... "*helps to orient* (oneself) *towards the teaching profession*" ... "*exposes one to the reality of mathematics teaching and classroom management over the long period*" ... "*more time is spent at school and it allows you to become acquainted with the administration of the school*".

For question 7: "What planning and lesson preparation did you have to do in order to achieve your outcomes for a mathematics lesson", the statements were:
"*meso- and micro planning*" ... "(using) *different teaching strategies*" ... "*planning the subject matter*" ... "*making the steps understandable* (for the learners)" ... "*concretised subject matter*".

In responding to question 8: "Do you think you were adequately prepared at college to achieve success in the teaching of mathematics lessons at school", 20 students (n = 22) answered in the affirmative.

Question 9: "What would you rate as a positive achievement during the teaching of mathematics lessons at school", evoked the following responses:
"(My) *confidence improved*" ... "*understanding learners*" ... "(have an) *open-minded approach*".

To question 10: "In your observation of mathematics lessons, how would you compare your teaching style with that of an experienced teacher", statements varied from:

"I have learned from the experienced teacher" ... "to make things much more practical for the learners" ... "the experienced teacher used old fashioned techniques" ... "I had more exposure to OBE training than the teacher" ... "I posed a threat to his teaching career in maths".

Summary of the results

In analysing the open-ended achievement questionnaire (SQ2), no differentiation between group responses was made at either the sub-scale or item (question) level. The two sub-scales *Achievement in the learning of mathematics* and *Achievement in the teaching of mat*hematics were set against the institutional (college-based) and field (school-based) experiences of the SYSTEM students. Qualitative reporting of students' responses in their perceptions of their achievements in the learning and teaching of mathematics was done.

Most of the time student responses were varied. A few questions reported uniform responses. For questions 6 and 8, the responses were homogeneous in indicating a preference for a teaching internship and being adequately prepared at college for teaching mathematics lessons during the internship, respectively. Question 8 responses were contradictory to the statements expressed by some SYSTEM students during the interviews (see paragraph 4.4.2), where the concern was that too much educational theory was taught with minimal exposure to practice. Question 3 highlighted the issue of students' self-efficacy (see paragraph 3.5.4) by affording them the opportunity to reflect about their possible weakness(es) as mathematics students. Such self-realisation could be construed by students in a constructive manner, as possibly self-assessing their performances and achievements in mathematics. Schunk (1981: 93) defines self-efficacy as judgements of one's capability to perform given activities.

Questions 1 and 5 revealed a predisposition in student perceptions towards a positive self-concept (see paragraph 3.5.4), that is, a belief that they could determine their own learning success (Reynolds & Walberg, 1992: 308). A student response (question 10) in being more exposed to OBE training than his/her mentor teacher, and another response of being a threat to the career of the mentor teacher, highlights the judgemental nature inherent in open-ended answering. However, a few mentor teachers acknowledged that "students have the knowledge of OBE and were applying it a lot of times", and that some of their (students) teaching styles were embedded in the problem-centred approach (see paragraph 4.4.2). Questions 7, 8 and 10 raised the issues of the mathematical abilities (see paragraph 3.5.4) of students in relation to planning and preparation of mathematics lessons and their perceptions of their teaching experience during the internship period. Although students were able to outline the manner in which their planning and preparations of mathematics lessons were executed, no acknowledgement was given to the assistance provided by their mentor teachers. The mentor teachers comments on the assistance provided to SYSTEM students ranged from "change their way of lesson planning" to "show them how lesson preparation is done at school" to "help students interpret the syllabi" (see paragraph 4.4.2). From a qualitative perspective, it was quite evident that SYSTEM students were concerned about task-related issues (Fuller's Task category) whereas the mentor teachers' concerns were with meeting the needs of the students (Fuller's Impact category) [see paragraph 4.3.3].

The physical (academic) achievements of SYSTEM students (see paragraph 3.5.2) comprised institutional and field assessments, measured in terms of allotted marks. The use of students' physical marks as a yardstick for evaluating and comparing processed data is both uncommon and demanding, given that many factors, both dispositional and environmental (see paragraph 3.5.4), may affect students' mathematics achievements. However, this study was designed in such a manner to link the perceptions of students to the realities of achievements at institutional and field settings. The research design was thus sufficiently influential in outweighing such an anomaly.

Table 6.10: Means and Standard deviations of physical marks achieved during subject examinations and internship evaluation

Physical Achievement Construct	Component	Group	Mean	Standard Deviation
Subject examinations (institutional achievement)	Mathematics I	Group 1	53,700	5,229
		Group 2	58,000	5,527
	Mathematics II	Group 1	55,900	5,971
		Group 2	54,667	5,836
Internship evaluation (field achievement)	Internship	Group 1	58,600	2,797
		Group 2	59,833	3,186

⇩

Number of successful completers of the SYSTEM Diploma course	
Group 1	Group 2
8/10 = 80%	7/12 = 58%

The mean scores in Table 6.10 revealed a homogeneous small range of scores for the physical achievements in examinations and internship for both groups. In context of this study, the relevance of the entry point for students into the teacher-training programme (whether from the Recovery programme or directly from Grade 12) becomes debatable (see paragraph 6.4).

6.3 GENERAL DISCUSSION OF THE RESULTS

OVERALL SUMMARY OF THE RESULTS

The aim of the study was to investigate the achievement in mathematics (as the dependent variable) of the SYSTEM students with special reference to Study orientation in mathematics, including Mathematics anxiety and Attitude towards mathematics (as the independent variables), and mentorship. Both quantitative (for the independent variables) and qualitative (for the dependent variable and the interviews) reporting of the results were done. In the statistical computations of the data from the scored questionnaires, some of the sub-scales of the independent variables were excluded from further quantitative analyses. Reasons varied from too few (many) items within the sub-scales to having low Cronbach's Alpha coefficients (< 0,5), indicating insufficient internal-consistency reliability of these sub-scales. The means of some SOM items (negative-loaded) were inverted in relation to the SOM scale (5-point rating scale) during the interpretation of the results. A 4-point rating scale was used for both Mathematics anxiety and Attitude towards mathematics in analysing Group 1 and Group 2 responses. Relatively high mean scores were reported for the fixed-response items ANX1, ANX3, ANX5, ANX11, ANX12, ANX14 ATT1, ATT3, ATT7 and ATT9 (equivalent to 3 on the anxiety/attitude scales) indicating some degree of homogeneous scoring from the dichotomous groups. The small standard deviations (in relation to the spans of the SOM/anxiety/attitude scales) reinforced the phenomenon of uniformed scoring amongst the average number of respondents. The qualitative processing of items within the inadequate sub-scales, during the frequency procedure reporting, was supported in theory by Tabachnick and Fidell (1996) [as cited in Hunt *et al.*, 2000: 15]. The frequencies of all items (expressed in percentages) reported on group responses towards the sentiments expressed in the item statements (see Appendices S, T and U). From the percentage scores of selected items, synopses of the general trends in the responses of the two groups towards the independent study variables were reported on.

Qualitative reporting of students' responses in their perceptions of their achievements in the learning and teaching of mathematics was done, revealing varied student responses. Few of the item questions elicited uniform responses.

INTERPRETATION OF THE OVERALL RESULTS

The selection of the variables for use in this study was based on the research undertaken by Maree *et al.* (1997: 3) who showed that there was a statistically significant association between aspects of Study orientation in mathematics, Mathematics anxiety and Attitudes towards mathematics in influencing the Achievement in mathematics. The design of the empirical component of this study was not to investigate the correlations between these variables but to rather use them as determinants to detect any significant differences between Group 1 and Group 2 responses. However, the inter-relatedness of these variables was acknowledged (see paragraph 3.6) in this study in context of their influential roles on the teaching and learning processes. This sub-paragraph integrates aspects of the literature review with the empirical findings of the study and reports on the inter-relatedness of the independent study variables with mathematics achievement for exploratory purposes.

The results for the variable Study orientation in mathematics revealed insignificant differences between group responses towards the effects of duration and time spent on learning and study (*Time* sub-scale), as well as towards the affective factors that could possibly influence learning and studying (*Emotional orientation* sub-scale). In other words, an average number of SYSTEM students were not too concerned about these aspects of study orientation. However, McLeod (1992: 575) states that a variety of large-scale studies provided a substantial amount of data that indicated that there was good reason to be concerned about affective factors. Bessant (1995: 339) posits that learning approaches (such as study orientation) are indicative of affective processes that can influence performance and achievement outcomes.

Chang (1994: 233) finds that there is a statistically significant correlation between students' study orientation and their academic achievement.

Results for the variable Mathematics anxiety revealed differences of small effect between group responses towards the anticipation, taking and receiving of mathematics tests (*Mathematics test anxiety* sub-scale), as well as towards being observed by others (learners, educators, etc.) and performing mathematical tasks (teaching) in the classroom (*Performance anxiety* sub-scale). The mean scores (of both groups) were relatively high for *Performance anxiety* in comparison to *Mathematics test anxiety* (see Table 6.6), suggesting that an average number of SYSTEM students agreed in experiencing some form of anxiety when teaching. This result supports that of Bessant (1995: 335) who finds that Performance anxiety has the highest loading (in terms of factor analysis) of the five anxiety dimensions (sub-scales). Norwood (1994: 251) reports a slightly negative relationship between mathematics anxiety and achievement in mathematics.

The results for the variable Attitude towards mathematics revealed differences of medium effect between group responses towards the learning of mathematics within an institutional setting (*Attitude towards the learning of mathematics* sub-scale). This sub-scale had mean scores (of both groups) equivalent to 3 on the 4-point attitude scale, suggesting that an average number of SYSTEM students agreed in having moderate predispositions towards the sentiments expressed in the attitudinal items of the sub-scale. This finding supports the contention expressed by McLeod (1992: 581) that attitudes involved feelings of moderate intensity. Furthermore, McLeod (1994: 641) states that confidence about learning mathematics has frequently been discussed as an attitude item. Several researchers have indicated a strong bond between attitudes and academic achievements (Knaupp, 1973: 9; Husèn *et al.*, 1974: 292, etc.).

The results of the variable Achievement in mathematics revealed varied perceptions from both groups of students towards the open-ended items of the two sub-scales *Achievement in the learning of mathematics* and *Achievement in the teaching of mathematics*. Qualitative analyses of the responses suggest that most SYSTEM students exhibited positive self-concepts and high self-efficacies towards the sentiments expressed in the item-questions. This finding supports the research done by Shiomi (1992) and Norwich (1987) [as cited in Grobler, 1998: 18] which shows that students with high self-efficacies had positive self-concepts towards mathematics.

It was also quite evident (from the students' responses) that most SYSTEM students were concerned about task-related issues (Fuller's Task category, see paragraph 4.3.3). This finding is contrary to that undertaken by Reed (1995: 211) who shows that students doing practice teaching were more impact-concerned (Fuller's Impact category, see paragraph 4.3.3), that is, meeting the (educational) needs of the learners. In the analyses of the interviews (see paragraph 4.4.3), in defining their roles as mentors, the mathematics teachers referred to their concerns towards the SYSTEM students' needs in relation to receiving classroom support and guidance. Specifically, the mentor teachers' concerns centred around providing adequate guidance, assisting with lesson planning and preparation, and supervising lesson presentations. These mathematics mentor teachers were thus impact concerned. This finding concurred to a certain degree with that of Furlong and Maynard (1995: 158), who state that their study showed that teachers were not only concerned with the intellectual development of their mentees, but also with the moral and emotional development of the students and to inculcate a positive attitude towards teaching. Winberg (1999: 16-23) states that recognising the needs of a person adapting to a new role and leading by example are challenges that a mentor has to respond to appropriately. Fuller (1969: 126) contends that the highest stages of professional development are those that are able to meet the needs of students (impact-concerns category).

Interpreting student responses to the mentors' dispositions towards them as open and enthusiastic encouragement (see paragraphs 4.4.2 & 4.4.3), a conjectured explanation could be that students' attitudes and anxieties were positively influenced under mentorship during the internship period. Cohen (1995: 29) posits that a mentee would respond to and rely on the observable behaviours of the mentor as the indicator of internal intentions or motives (cf. also Gardiner, 1995: 49).

None of the sub-scales of the three independent study variables reported any large differences of practical significance in Group 1 and Group 2 responses. All had d-values < 0,8. In the light of this result, *Research Question 2(a)* could now be addressed. There were no differences of practical significance in the perceptions of the two sampled groups from the SYSTEM (Phase II) study population, with regard to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics. The relevance of the Recovery programme (SYSTEM: Phase I) as a redress initiative and a possible conduit into teacher-training, was not influential enough for Group 2 students in having significantly different perceptions from Group 1 students (who had no exposure to any post-matriculation courses).

In answering *Research Question 2(b)*, the constructive comments of SYSTEM students about their performances and achievements in mathematics, within the constructs of learning and teaching mathematics (see paragraph 6.2.4), attested to the SYSTEM students' positive perceptions towards the project (Phase II). Against this background the number of successful completers (see Table 6.10), namely 68% (15 out of 22), should rank the SYSTEM Phase II programme in terms of the performances and achievements of its students in the Northern Cape as relatively successful.

6.4 CONCLUDING REMARKS

This study takes cognisance of the fact that other variables, not considered within the parameters of this study, could have also played a contributory role in influencing the achievements of SYSTEM students in mathematics. Phase I of SYSTEM (one-year redress programme) as a conduit of entry into Phase II, proved to have had no significant influence on the perceptions of Group 2 students. However, the four-year course of Phase II allowed the students to develop professionally (during internship) and this might have had a definite influence on how they viewed the project. In Chapter 7, a summary (theoretical and empirical) of the study is given, with recommendations proposed based on the project evaluation.

CHAPTER 7

SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

7.1 INTRODUCTION

This chapter provides an overall summary of the research, both from a theoretical and empirical perspective. The statement of the problem provides a brief synopsis of the transformation of the education and training system in post-1994 South Africa and the consequent gestation of SYSTEM. Within this contextual framework, the constructs of the study were aligned to the SYSTEM teacher-training programme, namely the learning of mathematics (institute-based) and the teaching of mathematics (field-based) [see Figure 3.1]. The literature review makes special reference to Study orientation in mathematics, Mathematics anxiety, Attitude towards mathematics, Achievement in mathematics and mentorship. An exposition on the method and procedure of the research is provided. The results, conclusion and limitations of the study are discussed. Finally, recommendations based on the outcomes of this study are proposed.

7.2 STATEMENT OF THE PROBLEM

SYSTEM was one of the first educational projects of the newly elected post-1994 government to address the historical imbalances within our education and training system.

The project provided a vehicle whereby historically disadvantaged mathematics and science students could access programmes (like SYSTEM Phase I) to gain entry into programmes at institutions of higher learning (like SYSTEM Phase II) [see paragraph 2.5.1]. The impetus for implementing SYSTEM was provided for by the TIMSS report (see paragraph 2.4) that rated the performances of South African learners in an international study on mathematics and science achievements as very poor. The success of SYSTEM ultimately resided in the performances and achievements of the students in the SYSTEM programmes (Phase I & Phase II) [see also *Research Question 2b*]. By examining the perceptions of these students (in Phase II), particularly towards the learning and teaching of mathematics, a better understanding could be obtained of the factors contributing to poor results. Within this contextual framework, this study made special reference to *Study orientation in mathematics*, *Mathematics anxiety* and *Attitude towards mathematics* as possible causative variables (independent) that could inhibit / enhance performance and achievement. The dependent variable was the *Achievement in mathematics* and was measured from a setting of institutional learning and field practice (internship). The selection of these variables, for use in this study, was based on research undertaken by Maree, Prinsloo and Claasen (1997: 3) which showed that there was a statistically significant association between aspects of Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics in influencing Achievements in mathematics. The design of the empirical component of this study was not to investigate the correlations between these variables but rather to use them as determinants to detect any significant differences between group perceptions. However, the inter-relatedness of these variables was acknowledged (see paragraph 3.6) in this study in context of their influential roles on the teaching and learning processes. (See also Figure 3.1, for a schematic representation of the delineation of the fields of measure.)

This study analyses SYSTEM as an educational redress initiative through the investigation of the performances and achievements in mathematics of the SYSTEM students in the Northern Cape. The aim of this research was thus to investigate the achievements in mathematics of SYSTEM students in the Northern Cape, with special reference to Study orientation in mathematics, including Mathematics anxiety, Attitude towards mathematics, and Mentorship.

The aims of the study were parametrized through the investigation of the following research questions:

Research Question 1

How did the transformative processes taking place within the education and training system of South Africa influence the gestation of SYSTEM?

Research Question 2

(a) Are there any significant differences in the perceptions of the two sampled groups from the SYSTEM (Phase II) study population, with regard to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics?

(b) How is the project evaluation of SYSTEM defined in terms of students' perceptions towards their performances and achievements in mathematics?

Research Question 3

How relevant was mentorship to the SYSTEM students during the internship period?

Research Question 4

Within the theoretical premises and the empirical results of this study, what recommendations emanating from the SYSTEM project are proposed?

The objectives of this study were to:

1. Describe the contextual framework of the SYSTEM project from a historical-educational perspective and within the ambit of educational transformation.

2(a). Explain the relevance of the Recovery programme (SYSTEM: Phase I) as a conduit into the teacher-training programme (SYSTEM: Phase II). The perceptions of two sampled groups, from different entry points, were analysed.

(b). Evaluate the SYSTEM project in terms of the students' perceptions towards their performances and achievements in mathematics.

3. Investigate the relevance of mentorship during the internship period.

4. Propose recommendations based on the findings of this study for either the reintroduction, modification or dissolution of SYSTEM. Such a recommendation should be seen against the background of transforming teacher-training programmes in South Africa.

7.3 AN OVERVIEW OF THE LITERATURE STUDY IN RELATION TO THE EMPIRICAL FINDINGS

Study orientation in mathematics focuses on the approaches on the pedagogy (the practice of how, what and when) of learning mathematics (see paragraph 3.2.2). No differentiation was made in this research between the various types of study orientations of SYSTEM students, as mentioned in studies undertaken by Marton and Säljö (1984: 38), Ramsden (1992: 8) and Biggs (1985: 187).

Bessant (1995: 339) states that learning approaches were indicative of affective issues that could influence performance and achievement outcomes. Magnusson and Svensson (2000: 6) posit that learning approaches are connected to study orientation. From the empirical results of this study, and in relation to *Research Question 2a*, the differences in group responses towards Study orientation in mathematics were not of practical significance (see paragraph 6.2.1), and it would appear that an average number of SYSTEM students (from the study population, N=22) were not too concerned about aspects of study orientation (see paragraph 6.3). According to McLeod (1992: 575), a wide variety of large-scale studies have shown that there was good reason to be concerned about affective issues in context of teaching and learning. Chang (1994: 233) finds that there was a statistical significant correlation between students' study orientation and their academic achievement.

Richardson and Suinn (1972: 551) define mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations." Bessant (1995: 327) posits that mathematics anxiety has become a euphemism for poor performance, low self-confidence, fear of failure, and negative feelings towards mathematics. Other researchers have investigated the causes of mathematics anxiety and found that, *inter alia*, weak mathematical background (Lussier, 1996: 828), teacher behaviour (Jackson & Leffingwell, 1999: 583), the nature of mathematics (Gourgey, 1992: 10), and beliefs about mathematics (Schoenfeld, 1988: 145), influenced proneness to mathematics anxiety. The causes of SYSTEM students' mathematics anxiety were not within the purview of this study. McAuliffe and Trueblood report (as quoted by Bessant, 1995: 38) that mathematics anxiety could be moderately correlated with state and trait anxiety. No classification of SYSTEM students' mathematics anxiety was made in terms of state and trait anxiety. The findings of the empirical results of this study revealed slightly noticeable differences in group responses towards Mathematics anxiety but not of practical significance (see *Research Question 2a* & paragraph 6.2.2), with an average number of SYSTEM students agreeing in experiencing some form of anxiety when teaching (*Performance anxiety* sub-scale) [see paragraph 6.3].

This finding supports that of Bessant (1995: 335) who finds that Performance anxiety had the highest loading (in terms of factor analysis) of the five anxiety dimensions (sub-scales). The influence of anxiety on achievement has been reported by Gaudry and Spielberger (1971: 7), and by Koran and Koran (1984: 793) [see paragraph 3.6]. Norwood (1994: 251) reports a slightly negative relationship between mathematics anxiety and achievement in mathematics. The inter-relatedness of mathematics anxiety and study orientation is highlighted in studies undertaken by Bessant (1995) and Steyn and Maree (2002) [see also paragraph 3.6].

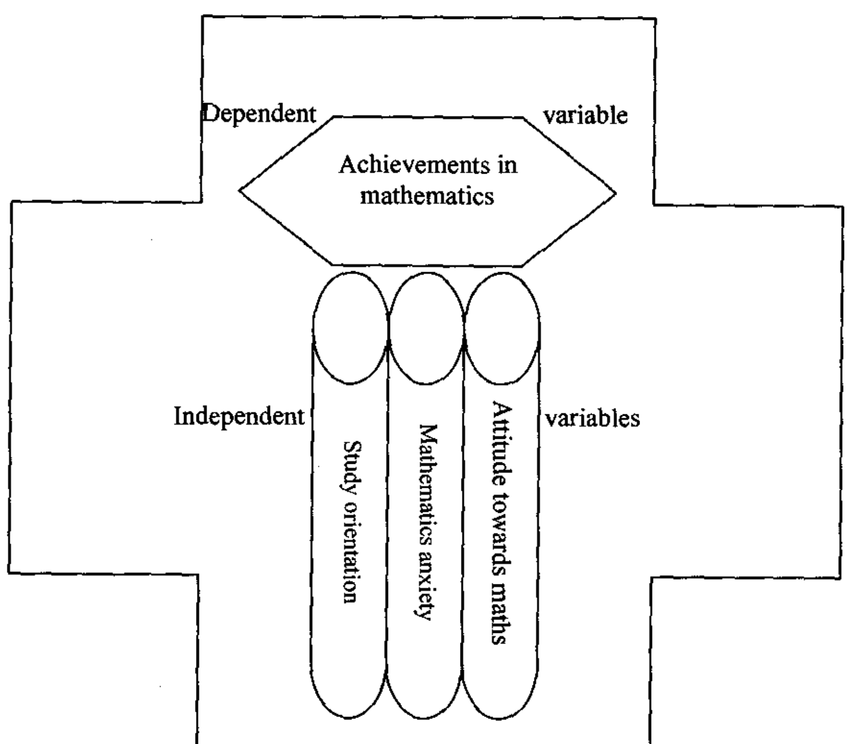
McLeod (1992: 581) defines attitude as the affective responses that involve positive or negative feelings of moderate intensity and reasonable stability. Ernest (1988: 290) states that *attitude towards mathematics* is a combination of the degree of students' liking of the subject and confidence in their mathematical ability. In terms of *Research Question 2a*, results of this empirical study revealed noticeable differences in Group 1 and Group 2 perceptions towards Attitude towards mathematics but of no practical significance. The results further suggested that an average number of SYSTEM students agreed in having moderate predispositions towards the *Attitude towards the learning of mathematics* sub-scale (see paragraph 6.3). This finding supports the contention expressed by McLeod (1992: 581) that attitudes involved feelings of moderate intensity. Furthermore, McLeod (1994: 641) states that confidence about learning mathematics has frequently been discussed as an attitude item. Several researchers have indicated a strong bond between attitudes and academic achievements (Knaupp, 1973: 9; Husèn *et al.*, 1974: 292, etc.). The influence of attitude on mathematics achievement is reported by Minato and Kamada (1996: 96), Husèn, Fagerlind and Liljefors (1974: 292) and Knaupp (1973: 9) [see paragraph 3.6]. Bessant posits that students' attitude towards mathematics appeared to be intertwined with the facilitating and debilitating effects of mathematics anxiety [see paragraph 3.6]. Hembree (1990: 46) reports a strong association between attitude and mathematics anxiety.

In defining achievement in mathematics, this study embraced its generic definition that pertains to the act of performing, attaining and accomplishing (see paragraph 3.5.2). Qualitative analyses of SYSTEM students' perceptions towards achievements in the teaching and learning of mathematics revealed varied responses (see paragraph 6.2.4). The empirical results suggested that most of the SYSTEM students exhibited positive self-concepts and high self-efficacies in their perceptions of their performances and achievements (see paragraphs 3.5.4 & 6.3). This finding support research done by Shiomi (1992) and Norwood (1987) [as cited in Grobler, 1998: 18] that shows that students with high self-efficacies had positive self-concepts towards mathematics. Hackett (1985: 47) finds self-efficacy to be a major predictor of mathematical achievement. Variances in mathematics achievement could be pegged to the influences of other cognitive and affective predictors (see paragraph 3.5.4). Other factors, not investigated in this study, associated with mathematical achievement, are *inter alia*, socio-economic status (Crane, 1996: 305), prior achievement in mathematics (Reynolds & Walberg, 1992: 306) and teacher's education (Monk, 1994: 125).

The definition of mentorship and mentoring is varied and multi-dimensional and in teacher-training the role of the mentor becomes more defined in terms of educational pedagogy (see paragraph 4.2.1). Winberg (1999: 3-4) states that mentoring is firmly rooted in teaching practice. He posits that the role of the mentor teacher is to provide assistance to trainee teachers to design, develop and maintain environments that facilitated learning. Stallion and Zimber (1991: 425) define mentoring as a nurturing and coaching process. In the qualitative analyses of the mentor/mentee interviews (see paragraph 4.4.3), it was evident (from the students' responses) that most SYSTEM students were concerned about task-related issues (Fuller's Task category, see paragraph 4.3.3). This finding is contrary to that undertaken by Reed (1995: 211) who shows that students doing practice teaching were more impact-concerned (Fuller's Impact category, see paragraph 4.3.3), that is, meeting the (educational) needs of the learners. The mentor teachers, in turn, were impact-concerned.

This finding concurred to a certain degree with that of Furlong and Maynard (1995:158), who state that their study showed that teachers were not only concerned with the intellectual development of their mentees, but also with the moral and emotional development of the students and to inculcate a positive attitude towards teaching. Winberg (1999: 16-23) states that recognising the needs of a person adapting to a new role and leading by example are challenges that a mentor has to respond to appropriately. Fuller (1969: 126) contends that the highest stages of professional development are those that are able to meet the needs of students (impact-concerns category). Interpreting student responses to the mentors' dispositions towards them as open and enthusiastic encouragement (see paragraphs 4.4.2 & 4.4.3), a conjectured explanation could be that students' attitudes, anxieties and performances were positively influenced under mentorship during the internship period. Cohen (1995: 29) posits that a mentee would respond to and rely on the observable behaviours of the mentor as the indicator of internal intentions or motives (cf. also Gardiner, 1995: 49).

The following schema outlines the embracing nature of mentorship in remediating factors (the study variables in this research) influencing the teaching and learning processes.



Ameliorating nature of mentorship

7.4 METHOD OF RESEARCH

7.4.1 Research design

This study used field survey-type techniques. A non-experimental survey was used to collect the data. A comparison of group responses towards the variables was explored in an *ex-post facto* design. Measurements were static (one-off) and no conclusions were made on developments or changes in the study variables as is done in longitudinal studies (see paragraph 1.3.2.1).

7.4.2 Population and sample

The study population size (N) for this study consisted of 22 SYSTEM Phase II students. There was a discernible dichotomous sub-group within Phase II, each with different achievement levels in mathematics and physical science. The sample for the mentor population consisted of nine mathematics mentor teachers from the schools that were identified for the placements of the SYSTEM students during their internship (see paragraph 1.3.2.2).

7.4.3 Instruments

A two-fold approach was used to elicit responses from the participating SYSTEM students and mentor teachers, namely the use of questionnaires and interviews (see paragraph 1.3.2.3).

- The use of questionnaires
- The use of interviews

7.4.4 Statistical techniques

Both quantitative and qualitative processing were used during the empirical research (see paragraph 1.3.2.4).

- The use of quantitative techniques
- The use of a qualitative technique

For the quantitative processing of the means, frequencies and coefficients, the primary Windows-based software programme Statistical Analysis System (SAS) for Windows Release 6.12 (1996) was used.

7.5 PROCEDURE

Prior to the commencement of empirical study, all of the 22 SYSTEM students and nine mathematics mentor teachers were invited to participate in the completion of the following questionnaires and / or interviews. A letter (see Appendix P) outlining the purpose of the study, as well as guaranteeing confidentiality, was handed over to the prospective respondents. A brief informative session was held with the students prior to the scoring / completion of the four questionnaires. This was done to explain the essence of their (students') contribution as well as the potential value of this research study. The participating students were urged to respond accordingly. Students were asked not to write their names on the questionnaires and were assured that their ratings and responses would be treated confidentially. The questionnaires were coded to distinguish between Group 1 and Group 2 responses. For the interviews, the author limited the student group-interview to eight students, four from Group 1 and four from Group 2. These audio interviews were conducted at the college and the interview was of the semi-structured type.

Permission to visit the placement schools to conduct interviews with the mathematics mentor teachers was obtained from the Northern Cape provincial education department (see Appendix Q). Prior to the commencement of these interviews, the mentor teachers were informed about the anonymity and confidentiality of their responses.

7.6 RESULTS

The objectives of this study (see paragraph 1.2) were addressed by the following research questions:

7.6.1 Research Question 1

How did the transformative processes taking place within the education and training system of South Africa influence the gestation of SYSTEM?

The need to create innovative, transformative, democratic and open learning process (SYSTEM Task Team, 1996: 9) within a contextual framework of educational transformation, became one of the first priorities of the newly elected post-1994 government. In particular, the gestation of SYSTEM was precipitated by the need for programmes to intervene in redressing the poor performances of our learners in mathematics and science (see paragraph 2.5.2) [SYSTEM Phase I: The Recovery programme], and the low number of qualified and competent science, mathematics and technology teachers (see paragraph 2.5.5) [SYSTEM Phase II: The teacher-training programme]. The impetus for implementing SYSTEM as a redress project was provided for by the TIMSS report on the poor performances of South African learners in an international study on achievements in mathematics and science (see paragraph 2.4).

7.6.2 Research Question 2

(a) Are there any significant differences in the perceptions of the two sampled groups from the SYSTEM (Phase II) study population, with regard to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics?

There were no differences of practical significance in the perceptions of the two sampled groups from the SYSTEM (Phase II) population, with regard to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics. None of the sub-scales, of the three independent variables, reported any large differences of practical significance (all had d-values < 0,8) in Group 1 and Group 2 responses (see Cohen's d-values in paragraphs 6.2.1, 6.2.2 & 6.2.3).

The relevance of the Recovery programme (SYSTEM: Phase I) as a redress initiative and a possible conduit into teacher-training, was not influential enough for Group 2 students in having significantly different perceptions from Group 1 students (who had no exposure to any post-matriculation courses). Table 6.10 (see paragraph 6.2.4) revealed no discernible differences in the mean scores of both groups for their physical (academic) achievements in subject examinations and internship evaluation.

(b) How is the project evaluation of SYSTEM defined in terms of students' perceptions towards their performances and achievements in mathematics?

Qualitative processing of the perceptions of SYSTEM students about their performances and achievements in mathematics, within the constructs of learning and teaching mathematics (see paragraph 6.2.4), attested to their constructive and positive perceptions towards the project (Phase II). Against this background, the number of successful completers (see Table 6.10), namely 68% (15 out of 22) should rank the SYSTEM Phase II programme and the achievement of its students in the Northern Cape as relatively successful.

7.6.3 Research Question 3

How relevant was mentorship to the SYSTEM students during the internship period?

Based on the qualitative processing of the mathematics mentor teachers' and students' perceptions on mentorship and mentoring, the responses during the interviews were overwhelming positive (see paragraph 4.4.2). The result attested to an acknowledgement by the mentor as providing professional guidance to the SYSTEM students, with the students in turn acknowledging the relevance of receiving on-site coaching and training from the mentor teachers, especially during the lengthy period of internship. Mentorship was a *sine qua non* for the internship period in the SYSTEM project.

7.6.4 Research Question 4

Within the theoretical premises and the empirical results of this study, what recommendations emanating from the SYSTEM project are proposed?

Numerous studies have revealed strong theoretical associations with performances and achievements in mathematics (see paragraphs 6.3 & 7.3). The project evaluation of SYSTEM was assessed against the performances and achievements of its students in the teaching and learning of mathematics respectively. With SYSTEM Phase II proving relatively successful (in the Northern Cape) [see paragraph 6.3] and in light of the statements contained in paragraph 2.7, modifications of the Phase II programme are recommended for use in current and future teacher-training programmes. These modifications are detailed in paragraph 7.8.

7.7 LIMITATIONS OF THE STUDY

Several factors have limited the generalisation of the results of this research (province-specific) from being interpreted as an evaluation of the SYSTEM project at a national level:

7.7.1 Sample size

The study population that participated in this research was small (N = 22) and may not have been representative of the typical South African constituency for teacher-training. The sample sizes for Group 1 (n = 10) and Group 2 (n = 12) was a direct consequence of the intake (and entry) of students into the project (see paragraph 1.3.2.2) and no random sampling was effected.

7.7.2 Instrumentation

The use of questionnaires

The questionnaire MA-SOM-T (see paragraph 3.2.3.1) was adapted and modified from the SOM questionnaire (for use at school level) of Maree *et al.* (1997). At the earlier stages of this research, no SOM questionnaire was ready for use at the tertiary level (see paragraph 3.2.3.1). The MA-MARS questionnaire (see paragraph 3.3.3.1) was adapted and modified from the MARS questionnaire of Suinn (1972) [see paragraph 3.3.3]. Both the MA-SOM-T and the MA-MARS were adapted and modified for use at tertiary level in the absence of (similar) standardised questionnaires for use in South Africa at this educational level. Furthermore, some sub-scales of the MA-SOM-T and the MA-MARS questionnaires were not sensitised to the demands of quantitative processing:

- MA-SOM-T: had a sub-scale with too few items (see paragraph 6.2.1).
- MA-MARS: had a sub-scale with too many items measured against the small sample population (n = 22) [see paragraph 6.2.2].

The exclusions of some sub-scales in the *MA-SOM-T*, the *MA-MARS* and the *Attitude towards mathematics* questionnaires (due to low alpha values of < 0,5) from further quantitative processing limited the range of the empirical investigation.

In the qualitative analyses of the open-ended *Achievement in mathematics* questionnaire (see paragraph 6.2.4), it was evident that some respondents had difficulty in comprehending the questions posed (in English). This could perhaps be ascribed to the fact that English for some may be their second or third language.

The use of interviews

The location of the venues for some of the interviews at the placement schools proved problematic (congested storeroom, noisy staff-room, in full view of a class), even though prior arrangements were made for isolated venues, since the interviews were to be audio-taped. Inaudible responses posed a challenge in the transcription of the interviews. Some of the respondents experienced difficulty in comprehending the questions posed (see paragraph 4.4.3). The author ascribed this to the fact that some of the mentor teachers were first time interviewees, or they could have simply been intimidated by the questions asked, or that English was not their first language. The questions were then rephrased.

7.7.3 A province-specific study

The lack of financial resources had confined this study to include only participants from the SYSTEM project in the Northern Cape and mentor teachers from the Kimberley educational district.

7.8 RECOMMENDATIONS

Present intervention initiatives by government and NGOs in addressing learners' poor performances in mathematics and science, as well as the large number of under-qualified and unqualified mathematics and science teachers, should take cognisance of the fact that this study, notwithstanding its inherent limitations, showed that some intervention programmes (like SYSTEM Phase I) had no influential effect in preparing students for higher education. Current teacher-training programmes should access lessons learnt from SYSTEM Phase II with regard to curricula transformation and should consider the benefits of an internship linked to some form of mentoring. Even though the SYSTEM project is no longer operational, it should serve as a benchmark for similar/related projects/programmes undertaken in the future.

The following recommendations, based on the results of the research, are proposed:

- Longitudinal studies be undertaken (pre - and post-testing), to measure any variances (developments or changes) in Study orientations in mathematics, Mathematics anxieties, Attitudes towards mathematics on students' achievements in mathematics.

- More research be done on the MA-SOM-T and the MA-MARS questionnaires to validate them as instruments of measure for use at tertiary levels.

- Since systemic educational transformation is an ongoing process in South Africa, teacher-training programmes should be transformed to incorporate mentorship of pre-service student teachers within an established internship period. From an institutional perspective, the focus of the curricula should not just be contextually cognitive but should also consider non-cognitive factors (anxieties, beliefs, attitudes, etc.) which can influence the teaching and learning processes.

- The evaluation of the SYSTEM project in all the nine provinces should be done at a national level. Several factors have limited the generalisation of the results of this research (done in the Northern Cape) from being interpreted on a national scale (see paragraphs 7.7.1 & 7.7.3).

7.9 CONCLUSION

In this research the achievements of SYSTEM students in the Northern Cape were analysed, with special reference to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics. An internship linked to a mentorship programme was reported upon. There were special attributes that could be associated with the mentoring of SYSTEM students at the placement schools. A collaboration of *esprit de corps* was established between the mentor and mentee. The entry level of students into the Phase II programme revealed no differences of practical significance in the perceptions of the sampled dichotomous groups towards the independent study variables. Phase I had no influential role in preparing Group 2 students for teacher-training. The transformative environment within which SYSTEM operated, provided the ideal opportunity for the post-1994 government to launch a range of redress initiatives in mathematics and science education. Notwithstanding the problems associated with the structure and functionality of the project, the successful completers of the Phase II programme attest to the relative success of SYSTEM students (Northern Cape) in their performances and achievements in mathematics at both the institutional and field levels. To sustain the momentum of transformation of our education and training system, lessons learnt from SYSTEM should serve as a benchmark for the envisaged reform and transformation of the FET and Higher Education sectors. In particular, educational transformation should not only be cognitively contextual, since this study has indirectly shown that the affective domain should receive more attention in curriculum development, teacher education and research on teaching and learning. By embarking on these initiatives, the current state of learners' and students' performances and achievements in mathematics and science may be ameliorated. A further spin-off could possibly be an increase in the number of suitably qualified mathematics and science teachers.

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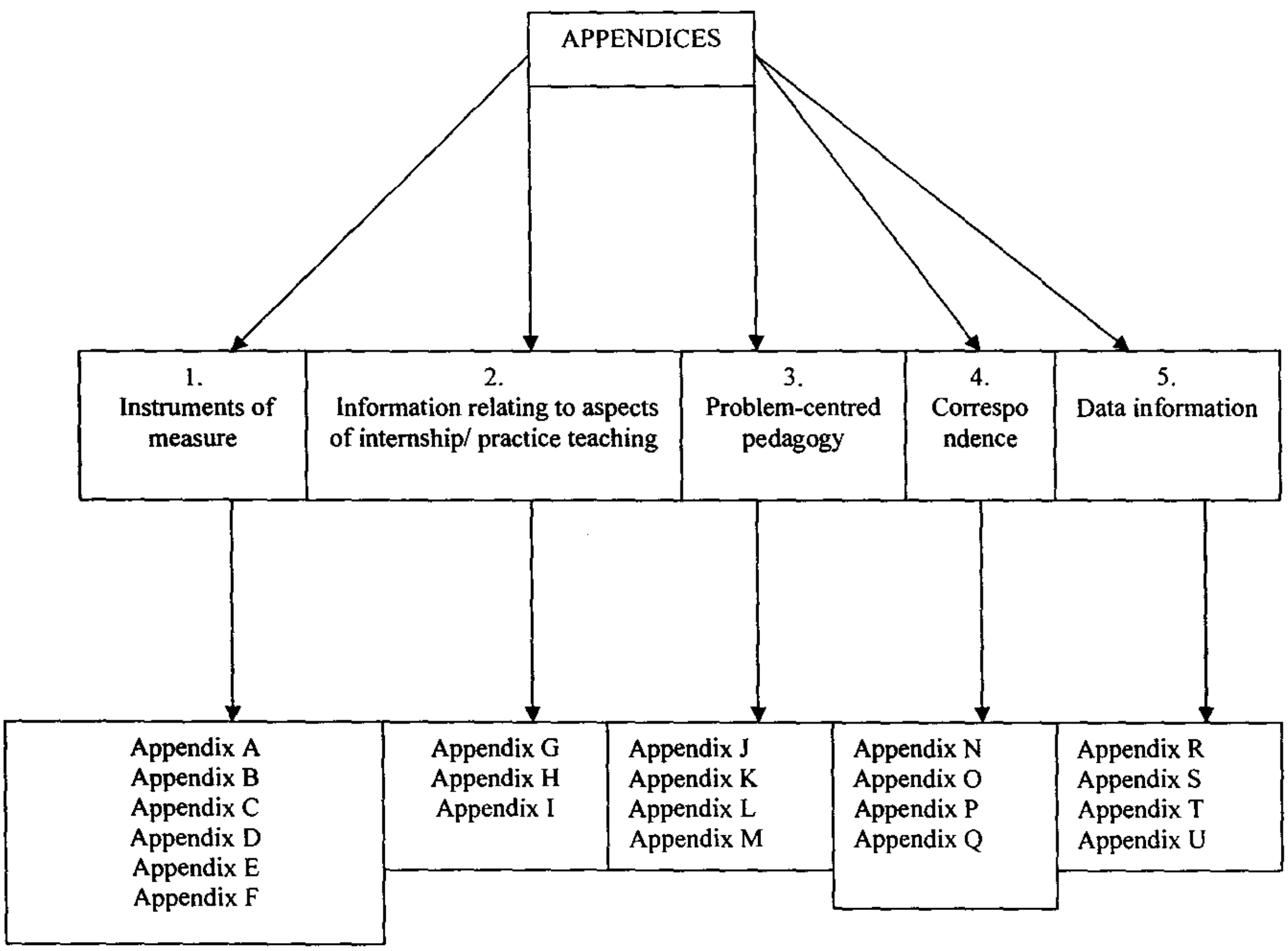
APPENDICES

The appendices presented in this research study have been categorised using the following schema:



1. INSTRUMENTS OF MEASURE

(a) Questionnaires

(i) Fixed-item response questionnaires:

APPENDIX A: STUDY ORIENTATION IN MATHEMATICS (MA-SOM-T) QUESTIONNAIRE (SQ4)

APPENDIX B: STUDENT TEACHER'S MATHEMATICS ANXIETY (MA-MARS) QUESTIONNAIRE (SQ3)

APPENDIX C: STUDENT TEACHER'S ATTITUDE QUESTIONNAIRE (SQ1)

(ii) Open-ended questionnaire:

APPENDIX D: STUDENT TEACHER'S ACHIEVEMENT QUESTIONNAIRE (SQ2)

(b) Interviews

(i) Structured interview:

APPENDIX E: INTERVIEW SCHEDULE

(ii) Semi-structured interview:

APPENDIX F: INTERVIEW GUIDE

APPENDIX A

M-SQ4 / PM-SQ4

STUDY ORIENTATION IN MATHEMATICS (MA-SOM-T) QUESTIONNAIRE (SQ4)

Kindly complete this questionnaire. Your responses will be treated **strictly confidentially**. The purpose of this questionnaire is to measure your study orientation towards mathematics during your tenure as pre-service SYSTEM students.

The following is an explanation of the SOM scale:

SOM scale

1= Rarely	0 to 15% of the time
2= Sometimes	16 to 35% of the time
3= Frequently	36 to 65% of the time
4= Generally	66 to 85% of the time
5= Almost always	86 to 100% of the time

Statement: As a pre-service SYSTEM student teacher ....

1. I enjoy preparing for tests and exams in maths.	1	2	3	4	5	
2. I postpone my maths homework and do something I enjoy more.	1	2	3	4	5	
3. I like doing maths alone at home.	1	2	3	4	5	
4. I become very anxious when studying for Abstract Linear Algebra.	1	2	3	4	5	
5. I will work on a maths problem for hours until I can solve it.	1	2	3	4	5	
6. when doing maths homework, I make careless mistakes.	1	2	3	4	5	
7. I prefer study maths to any other subject at college.	1	2	3	4	5	
8. I prefer having a maths mentor to assist me with the tasks in maths.	1	2	3	4	5	
9. I prepare for tests/exams by working out previous question papers.	1	2	3	4	5	
10. after working on maths for a while, I cannot concentrate any more.	1	2	3	4	5	
11. I prefer studying in a group to working alone on maths.	1	2	3	4	5	
12. unhappiness or frustration prevents me from working hard in maths.	1	2	3	4	5	
13. I am happy with my study habits for maths.	1	2	3	4	5	
14. I feel intimidated by the maths knowledge of my fellow classmates.	1	2	3	4	5	
15. I work every day to keep my Maths homework up to date.	1	2	3	4	5	
16. personal problems are why I cannot do my best in maths.	1	2	3	4	5	
17. I will always catch up on lost work in maths.	1	2	3	4	5	
18. I do not enjoy spending too much time in solving problems in maths.	1	2	3	4	5	
19. I enjoy working out Calculus problems.	1	2	3	4	5	
20. I become sleepy, tired or bored when I start doing maths.	1	2	3	4	5	

(*Acknowledgement: Modified and adapted from the original source: HSRC, 1996*)

Thank you for your kind co-operation.

M-SQ3/PM-SQ3

APPENDIX B

STUDENT TEACHER'S MATHEMATICS ANXIETY (MA-MARS) QUESTIONNAIRE (SQ3)

[The Modified and Adapted Mathematics Anxiety Rating Scale]

Kindly complete this questionnaire. Your response will be **strictly confidential.**

The purpose of this questionnaire is to measure what anxiety, if any, you may have experienced as SYSTEM student teachers within the constructs of the learning of mathematics at college, and the teaching of mathematics during internship. Three strands will be explored in order to obtain a measure of students' anxiety to the learning and teaching of mathematics, namely: Mathematics Test Anxiety, Performance Anxiety and General Evaluation Anxiety.

For each of the statements below, please indicate the extent of your agreement or disagreement by placing a cross (X) in the appropriate column. There is no correct or incorrect answer to any of the statements.

ANXIETY SCALING

1= strongly disagree
2= disagree
3= agree
4= strongly agree

Statement: As a pre-service student teacher I experienced some form of anxiety when.......

1. getting ready to study for a mathematics test.	1	2	3	4	
2. working out a concrete, everyday application of mathematics.	1	2	3	4	
3. teaching a mathematics lesson at school.	1	2	3	4	
4. starting a new chapter in the mathematics course.	1	2	3	4	
5. someone watches me teach mathematics to learners at a school.	1	2	3	4	
6. waiting for a mathematics test to be returned on which I expect to do well.	1	2	3	4	
7. observing a teacher at the school teaching a mathematics lesson.	1	2	3	4	
8. thinking about beginning a mathematics assignment.	1	2	3	4	
9. doing a word problem in calculus.	1	2	3	4	
10. opening a mathematics textbook and seeing a full page of problems.	1	2	3	4	
11. thinking about a mathematics test five minutes before it begins.	1	2	3	4	
12. being asked to teach an unprepared mathematics lesson.	1	2	3	4	
13. having to explain a mathematics problem on the board to fellow students.	1	2	3	4	
14. sitting in the classroom and waiting for a lesson evaluation from my lecturer.	1	2	3	4	
15. being asked to answer a mathematics question by my lecturer.	1	2	3	4	
16. being asked to solve an abstract vector algebra problem.	1	2	3	4	
17. having to teach according to the features of an Outcomes-Based lesson.	1	2	3	4	
18. having to work in groups to solve a problem.	1	2	3	4	
19. thinking about a mathematics test one day in advance.	1	2	3	4	
20. walking to a mathematics class at college.	1	2	3	4	

Thank you for your kind cooperation.

APPENDIX C

M-SQ1/PM-SQ1

STUDENT TEACHER'S ATTITUDE QUESTIONNAIRE (SQ1)

Kindly complete this questionnaire. Your response will be **strictly confidential**.
The purpose of this questionnaire is to establish the attitudes pre-service SYSTEM student teachers have within the constructs of the learning of mathematics at college, and the teaching of mathematics during internship.

Definition of attitude: "Attitude is a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object" (Fishbein & Ajzen).

For each of the statements below, please indicate the extent of your agreement or disagreement by placing a cross (X) in the appropriate column. There is no correct or incorrect answer to any of the statements.

ATTITUDE SCALING

1= strongly disagree
2= disagree
3= agree
4= strongly agree

1. I have enjoyed learning mathematics at college.	1	2	3	4	
2. I was not self- motivated to work very hard on my mathematics lessons.	1	2	3	4	
3. Learning mathematics was boring and tedious.	1	2	3	4	
4. My internship made me appreciate the joy of teaching mathematics.	1	2	3	4	
5. Mathematics was too abstract and difficult for me.	1	2	3	4	
6. My teaching style made it easy for learners to understand mathematics.	1	2	3	4	
7. I was very calm and relaxed when doing mathematics problems.	1	2	3	4	
8. My mentor mathematics teacher at school was of little assistance to me.	1	2	3	4	
9. I preferred learning university mathematics to college mathematics.	1	2	3	4	
10. I enjoyed working with other mathematics teachers at school.	1	2	3	4	

Thank you for your kind cooperation.

M-SQ2/PM-SQ2

APPENDIX D

STUDENT TEACHER'S ACHIEVEMENT QUESTIONNAIRE (SQ2)

Kindly complete the following questions that deal with your perceived achievements in mathematics and during your teaching internship.
The questions are formulated to reflect your experiences as pre-service mathematics student teachers at the college and in the classroom.

Questions 1-5 relate to your perceived achievements in mathematics at college.

1. Describe one of the most important achievements you think you have made in your study of mathematics at the college.

....

....

2. What special aspects of your mathematics education have prepared you for teaching?

....

....

3. What would you describe as your weakness as a mathematics student?

....

....

4. Explain the role you think your mathematics lecturer played in helping you achieve an understanding of mathematics.

....

....

5. What qualities do you think a mathematics student must possess in order to succeed in mathematics?

....

....

Questions 6-10 relate to your perceived achievements during teaching internship.

6. Describe reasons why you would prefer either a teaching internship period or practice teaching sessions.

....

....

....

7. What planning and lesson preparation did you have to do in order to achieve your outcomes in a mathematics lesson?

....

....

....

8. Do you think you were adequately prepared at college to achieve success in the teaching of mathematics lessons at school?

....

....

....

9. What would you rate as a positive achievement during the teaching of mathematics lessons at school?

....

....

....

10. In your observation of mathematics lessons, how would you compare your teaching style with that of an experienced mathematics teacher?

....

....

Thank you for your kind cooperation.

APPENDIX E

INTERVIEW SCHEDULE

STRUCTURED INTERVIEWS WITH THE MATHEMATICS MENTOR TEACHERS SYSTEM PROJECT (PHASE II): INTERNSHIP PERIOD-YEAR THREE

- Your responses will be treated strictly confidentially.
- Please feel free to answer as honest and objective as possible.
- Please take your time in answering each question posed.
- These questions were formulated to assess the SYSTEM students' achievements during their internship period from the mentors' perspective.

POSSIBLE QUESTIONS FOR INTERVIEW:

1. WHAT DO YOU THINK YOUR ROLE AND RESPONSIBILITIES WERE AS A MATHS MENTOR TEACHER FOR THE SYSTEM STUDENTS?
2. WHEN YOU WERE OBSERVING THE SYSTEM STUDENTS IN THE CLASSROOM, HOW DID THEY HANDLE CLASS DISCIPLINE AND CONTROL?
3. IN WHICH WAY DID YOU ASSIST THE SYSTEM STUDENTS WITH CLASSROOM MANAGEMENT?
4. IN WHICH WAY DID YOU ASSIST THE SYSTEM STUDENTS WITH LESSON PLANNING AND PREPARATION?
5. IN WHICH WAY DID YOU ASSIST THE SYSTEM STUDENTS WITH THEIR OWN TEACHING STYLE AND METHODOLOGY?-DID THEY TEACH USING THE PROBLEM – CENTRED APPROACH?
6. WHAT IS YOUR OPINION OF THE SYSTEM STUDENTS COMPARED TO NON-SYSTEM STUDENT TEACHERS?
7. WHAT PROBLEMS, IF ANY, DID YOU EXPERIENCE WITH MENTORING YOUR GROUP OF SYSTEM STUDENTS?
8. WHAT ROLE DID THE SYSTEM STUDENTS PLAY IN THE ADMINISTRATIVE DUTIES OF THE SCHOOL AND EXTRA-MURAL ACTIVITIES?
9. DESCRIBE THE SUCCESS (ADVANTAGES) OR FAILURES (DISADVANTAGES) OF THE INTERNSHIP PERIOD.
10. OPEN-QUESTION: YOUR CLOSING STATEMENT ON THE SYSTEM STUDENTS OR/AND INTERNSHIP PERIOD.

APPENDIX F

INTERVIEW GUIDE

SEMI-STRUCTURED INTERVIEW WITH A GROUP OF SYSTEM STUDENTS

Reflect on:

- The training provided by the college in preparation for the internship period.
- Describe how you felt when you first met your mathematics mentor teacher.
- What was the nature of your relationship with your mathematics mentor teacher?
- What did you gain from this mentoring relationship?
- Identify points that you think you have in common with your mathematics mentor teacher.
- From your experience, what changes need to be made to make mentoring operational in our schools?
- Who should be involved in evaluating the mentoring programmes at the placement schools?

2. INFORMATION RELATING TO ASPECTS OF INTERNSHIP/TEACHING PRACTICE

APPENDIX G: GUIDELINES FOR STUDENTS DURING THE INTERNSHIP PERIOD

APPENDIX H: REPORT SUBMITTED ON TEACHING PRACTICE

APPENDIX I: RECORD OF EVALUATION LESSONS

APPENDIX G

GUIDELINES FOR STUDENTS DURING THE INTERNSHIP PERIOD

INSTRUCTIONS TO SYSTEM STUDENTS

1. This session will be from 3 April – 6 December 2000

2. During this session students are expected to :
   - do an observation assignment-General Information during April;
   - complete observation reports on 16 learning experiences presented by mentors/teachers at school;
   - draw up 3 schemes of work (3 terms) to indicate the planning for each major subject; and
   - present 150 learning experiences in the major subjects of which 50 must be evaluated by lecturers / mentors collectively / individually. Subject lecturers will plan visits to your class to do continuous and summative evaluation.

   These Learning experiences must be recorded in your file.
   - do an action research project;
   - attend contact sessions at College of Education once a week on Wednesdays;
   - complete four (4) sets of teaching media;
   - complete weekly reflection reports (Lecturer, mentor, student;)
   - mark books, tests and examination under the supervision of the mentor; and
   - be involved in extra-mural activities where possible.

3. Students should start off in Grade 10 for the first term and gradually rotate between grades 10 and 11 for the next two terms.

4. All lessons / learning experiences must be prepared properly and presented competently, using all the teaching skills and knowledge you have obtained from the College.

5. General Remarks for all students regarding assessment:

- a record of assessed learning experiences must be filled in;
- after each evaluation lesson the lecturer's evaluation mark must be entered;
- take note of the different points on the evaluation form according to which your performance is going to be judged;
- prepare your lessons and teaching media properly;
- contact relevant lecturers for guidance and teaching media;
- note that permission must be obtained for the use of the school or college apparatus and replace them as soon as possible;
- ensure that all textbooks borrowed from the school must be returned at the end of each session;
- before starting a lesson, make sure about the following:

  give your planned learning experience to the lecturer (you are allowed to use brief notes on a loose sheet), be punctual for lessons, clean chalkboard, greet learners properly, introduce the lecturer, create the right atmosphere and have everyone's attention;
- no student is allowed to change the timetable;
- no re-evaluation of assessed learning experiences; and
- no demonstration lessons may be used for evaluation lessons, only steps or procedures may be used.

6. Although the practical experience in the classroom remains the first priority, it is expected that every student should assist in extra-curricular activities to gain experience in coaching and organizing such activities.

7. On his/her arrival at the school, each student will given the Principal his/her <u>Report Form On Teaching Practice.</u> Section A must be completed by the student. Kindly request the Principal to return it to the College. It is feedback from the school to the College.

8. The student must recognise the authority of the Principal and the class teacher and any task they may give him/her should be executed willingly. Students should be polite, courteous and co-operative towards members of staff. Take an interest in the pupils, but you should not

become too familiar with them. Permission for any absence must be obtained from the Principal.

9. Students are guests at the school and we expect them to behave professionally at all times. Make sure that your conduct, personal appearance, preparation and presentation of lessons are above reproach. You are expected to conform to the norms and rules of the host school.

10. Time must be used productively. You must use your time by giving lessons, attending other lessons for observation or assisting the teacher in the classroom. A student must not absent himself/herself from classes to lurk in the staff-room or elsewhere.

11. You are expected to mark a couple of books under the guidance of the mentor. Try to take note of common mistakes made by the pupils and how you can correct them.

12. Make sure that your files are professionally dressed, tidy, clearly labeled and have all the information required. Files must be handed in to your class lecturer by 10 November 2000.

13. Write a letter of thanks to the Principal and staff after the internship period

We trust that you will enjoy this session and find it an enriching and stimulating experience.

Source: Olivier (2000: 3-4)

APPENDIX H

REPORT SUBMITTED ON TEACHING PRACTICE

SECTION A: (to be filled in by the student)

STUDENT:.................................... YEAR:........................

COURSE/ CLASS:............................ YEAR OF STUDY:..........

PERIOD OF VISIT TO SCHOOL: From.......................to..........................

NAME OF SCHOOL:...

ADDRESS OF SCHOOL:...
....
....

SECTION B: (to be filled out by the principal and/ or class teacher)

1. Number of days at school:...................... Days absent:.........................

2. Number of lessons taught:......................

3. General Performance (Please rate on 5-point scale: 5=good, 0= poor)

   3.1 Personality.................................... 5 4 3 2 1 0

   3.2 Personal Appearance......................... 5 4 3 2 1 0

   3.3 Preparation of lessons....................... 5 4 3 2 1 0

   3.4 Presentation of lessons....................... 5 4 3 2 1 0

   3.5 Class control.................................. 5 4 3 2 1 0

Please comment on:

3.6 Attendance (regular, punctual):..

3.7 Participation in school activities:..

3.8 Attitude towards members of staff:...

3.9 Attitude towards the learners:...

3.10 Assessment of student as future teacher:...

....

4. General remarks (recommendations, problems)..

....

....

SCHOOL STAMP

SIGNATURE OF PRINCIPAL

Please give this report to the student or monitor on the last day of the Teaching practice session.

OR

Return to: The Amalgamated College of Education
Private Bag X 5047
KIMBERLEY
8301

APPENDIX I
RECORD OF EVALUATION LESSONS

STUDENT'S NAME:...

COURSE AND CLASS GROUP: ....

SCHOOL:... **YEAR:.................**

LESSON NUMBER	DATE TAUGHT	GRADE	SUBJECT AND SECTION	TOPIC	LANGUAGE MEDIUM	%	SYM-BOL	SIGNATURE OF ADJUDICATOR
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

3. THE PROBLEM-CENTRED PEDAGOGY

APPENDIX J: PROBLEM-CENTRED APPROACH

APPENDIX K: GUIDELINES FOR PLANNING A PROBLEM-CENTRED MATHEMATICS LESSON

APPENDIX L: SAMPLE OF A PROBLEM-CENTRED LESSON

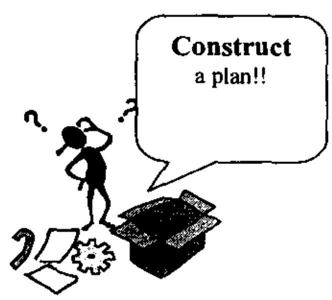
APPENDIX M: SAMPLE OF AN EVALUATION SHEET FOR A PROBLEM-CENTRED MATHEMATICS LESSON

APPENDIX J

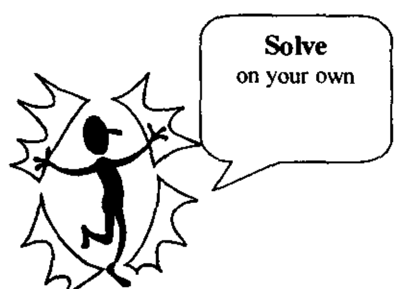
PROBLEM-CENTRED APPROACH

Problem:

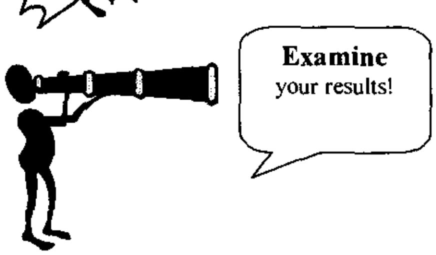
- What does the problem tell me?
- What does the problem ask me?
- What can I introduce to get started?
- Is there a pattern?
- Can I discover how or why?
- Can I break down the problem?



- Formulate the problem in your own words.
- Be creative and try various approaches to the problem.
- Design algorithms or list of steps which covers essential features of the problem.
- Draw sketch, graph or table to assist you.



- Be guided step-by-step by your plan.
- Formulate and use logical strategies for finding a solution.
- Set out solution in an orderly manner.



- Is the solution acceptable?
- What can I learn from the solution?

(Adapted from Hassan, 2000: 34)

APPENDIX K

GUIDELINES FOR PLANNING A PROBLEM-CENTRED MATHEMATICS LESSON

<table>
<tr>
<td rowspan="2">Note:
All phases of the lesson must reflect continuous evaluation AND any necessary remediation</td>
<td colspan="3">Lesson Plan Guideline

School: ____________ Time: ____________
Date: ____________ Duration of Lesson: ____________
Subject: ____________ Standard: ____________
Topic: ____________ Medium: ____________
Class: ____________ No. of Learners: ____________</td>
</tr>
<tr>
<td colspan="3">AIMS (Refer to Subject Didactics Mathematics I Study Guide – 7040712: Page 5–6)
1. Societal Aim(s): ____________
2. General Teaching / Learning Aim(s): ____________
3. Specific Aim(s) of Mathematics Education: ____________
NB: Topic (Concept) to be taught MUST be mentioned

LESSON OBJECTIVE
During the lesson the learners ____________ and at the end of the lesson ____________ [NB: must include CONDITION, PERFORMANCE (ACTION VERBS) and CRITERIA]</td>
</tr>
<tr>
<td>LESSON PHASE & STRATEGY</td>
<td>SUBJECT MATTER</td>
<td>ROLE OF TEACHER/ FACILITATOR</td>
<td>ROLE OF LEARNER</td>
</tr>
<tr>
<td>INTRODUCTION
(Recall and Integration)

problem-posing or game-playing
or
inductive method
etc.</td>
<td>Mention only the core ideas, i.e. the nucleus theme</td>
<td>• Meaningful word-problems which fall within life-world of the learners
• Effective introduction
• Provide opportunities for learners to solve problems
• Acceptance/interventions

Teaching Media:</td>
<td>• Learners must understand word-problems and make associations with existing knowledge
• Discover method of solution
• Verbalize their options

Learning Media:</td>
</tr>
</table>

PRESENTATION Problem-posing or problem-solving or question and answer or inductive method	Step 1 Nucleus theme only Step 2 Nucleus theme only Step 3 Nucleus theme only Etc.	• Using activities (on board, transparency, worksheet, etc) to allow learners to solve problems on their own • Guide/assist learners: provide remedial assistance • Posing of questions (correct use of subject vocabulary and the effective use of media) • Promote 3-way communication • Listen sympathetically to self-structured solutions • Provide alternative solutions • Continuous evaluation • Create atmosphere of emotional and psychological safety Teaching media:	• Learners structure own solutions to problems / contribute to the solution of the problem or work in groups • Verbalize their effort(s) Learning Media:
CONTROL Question and answer or written assignment or problem-solving	Assessment of newly acquired knowledge	• Assess newly acquired concepts by verbal evaluation, remaining activities on board, transparency worksheet or exercise from textbook • Include work from introduction and presentation • Attention to remediation • Differentiation Teaching media:	• Learners work mainly on their own • Verbalize their efforts on request Learning Media:
APPLICATION Evaluation, Mastering	Consolidation of newly acquired concepts (knowledge) Written assignment	• Further problem-solving or exercises for self-discovery; homework/assignment • Differentiated problems Teaching media:	• Must think logically, set out solutions orderly • Use knowledge gained (intuitive) to complete homework/assignment Learning Media:

(Hassan, 2000: 35)

APPENDIX L

SAMPLE OF A PROBLEM-CENTRED LESSON

School:	Homevale Senior Secondary School	**Medium**:	English
Date:	04 May 2000	**Time**:	08:30 – 09:00
Grade:	10	**Duration**:	30 min
Subject:	Mathematics	**Composition**:	Heterogeneous
Topic:	Square of a Binomial	**No. of Learners**:	39

Teaching and Learning Strategy: Problem-centred approach (socio-constructivism).

Aims:

1. Societal Aims

To work towards the development of the South African society and the empowerment of its people through the acquisition of mathematical knowledge and understanding, in order to use this knowledge in everyday life and in the performance of their tasks. To strive towards the creation of an independent and self-sufficient future generation.

2. General teaching and learning aims

To develop independent, confident and self-critical citizens, as well as to develop problem-solving capabilities and to encourage a co-operative learning environment.

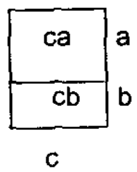
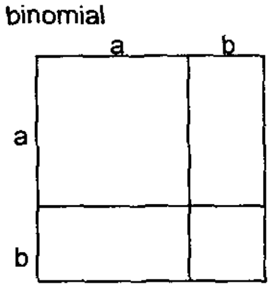
3. Specific aims of Mathematics Education

To enable pupils to gain mathematical knowledge and profiency, enabling them to apply Mathematics to other subjects and in daily life. To develop intuitive and calculating skills in finding the product of polynomials

4. Lesson Objective

During the lesson the learners must construct and induce a rule to find the square of a binomial and at the end of the lesson apply the rule to complete an assignment within a specified period of time, with accuracy and with minimal assistance provided by the teacher.

LESSON PHASE & STRATEGY	SUBJECT MATTER	ROLE OF TEACHER/ FACILITATOR	ROLE OF LEARNER
INTRODUCTION Problem-posing	<u>Step 1</u> Concretisation of area concept	Instructions concerning the activities are given. Problems are developed to reflect RDP-projects at a local municipality around land development. Learners are encouraged to voice their approval/criticism after intense analysis of identified topographical sectors.	Learners analyse the city planners' topographical maps, profile the sectors, and do estimations of areas of irregular and regular quadrilateral sectors of the map. Using the physical dimensions provided
Heuristic method	<u>Step 2</u> Area formulas of a square and rectangle	Teacher direct activities to the heuristic derivation of the areas for a square and rectangle <u>Teaching Media</u>: Topographical Map	Learners recall and integrate pre-knowledge in order to do formulation. <u>Learning Media</u>: Topographical maps

RESENTATION Recall Area formula 	<u>Step 1</u> Multiplication of a monomial with a binomial	Teacher encourage learners to establish a rule for multiplying a monomial with a binomial and vice versa	Learners affirm the application of the distributive property of multiplication over addition, in order to construct a solution to the problem $c \times (a + b)$ $=(c \times a) + (c \times b)$ $= ca + cb$
Inductive method	<u>Step 2</u> The square of a binomial 	Teacher provides each group with a set of two different rectangles and two different squares. Instructions concerning the activities are given	Learners, placed in groups: • Arrange the set of figures to form a "complete" square • Workout the areas of each piece of figure • Relate, inductively, the total area of the "complete" square to the areas of all the figures which make up the "complete" square
	<u>Step 3</u> Devising a rule for finding the square of a binomial	Teacher instruct groups to devise a rule: 1.by inspection 2. by using the distributive property <u>Teaching media</u>: Demonstration set of figures	Learners should induce: i. square the first term ii. +/- twice the product of the two terms iii. square the last term $(a + b)(a + b)$ $= (a \times a) + (a \times b) + (b \times a) + (b \times b)$ $= a^2 + ab + ab + b^2$ $= a^2 + 2ab + b^2$ <u>Learning media</u>: Set of figures cut from cardboard for each group
CONTROL/APPLICATION Mastering	Consolidation of rule	Teacher refer to worksheet: $(2a + 3b)^2 = \ldots$ etc.	Learners now work mainly on their own
Integration	Extends use of rule to the multiplication of two different binomials	$(2a + 3b)(4a - b) = \ldots$ etc. <u>Teaching media</u>: Worksheet	<u>Learning media</u>: Worksheet

(Adapted from Hassan, 2000: 37-38)

APPENDIX M

SAMPLE OF AN EVALUATION SHEET FOR A PROBLEM-CENTRED MATHEMATICS LESSON

Mathematics Lesson Evaluation:
The problem-centred approach

Student: ____________________ Course: ____________________
School: ____________________ Grade: ____________________
Lesson: ____________________ Date: ____________________

CATEGORIES & CRITERIA	SCORE	1	2	3	4	5
Personal	Bearing, manner, voice and appearance					
	Subject knowledge					
	Sub-total					
Planning and Preparation	The extent to which the lesson fosters and develops societal aims					
	The extent to which the lesson fosters and develops teaching and learning aims					
	The extent to which the lesson fosters specific aims of mathematical education					
	The amount and nature of content					
	The degree of differentiation reflected in lesson notes					
	Sub-total					
Introduction and Presentation	Effectiveness of the introduction					
	Enough meaningful word problems					
	To what extent was a lesson strategy identifiable					
	The amount of learner contribution to solving problems					
	The extent of continuous evaluation of learners' solutions					
	The amount of necessary remediation					

Introduction and Presentation	The creation of an atmosphere of emotional and psychological safety					
	Effective use of suitable media					
	Subject vocabulary Use and type of questions					
	Individual or group attention					
	Sub-total					
Control	Achievement of lesson aim					
	Assignment of control / evaluation					
	Completion of lesson in time allocated / lesson tempo					
	Sub-total					

General Comments:

____

____

____

____

____

____

____

Percentage	

Adjudicator: ____________________

Date: ____________________

<u>**SCALE:**</u> 1= Poor; 2 = Below Average; 3 = Average; 4 = Above average; 5 = Very good

(Hassan, 2000: 39-40)

4. CORRESPONDENCE

APPENDIX N: EM1: E-MAIL FROM PROFESSOR K. MAREE - 29 JANUARY 2003

APPENDIX O: EM2: E-MAIL FROM PROFESSOR K. MAREE - 5 FEBRUARY 2003

APPENDIX P: LETTER TO THE SYSTEM PRE-SERVICE STUDENT TEACHER

APPENDIX Q: PERMISSION TO CONDUCT INTERVIEWS

APPENDIX N

EM 1: E-MAIL FROM PROFESSOR K. MAREE - 29 January 2003

Logged in as .. nhassan@***.co.za**

Dial-up FAQ Privacy Policy AUP POP3 Support Suggestion Logout

Message in Inbox

From: "Prof. J.G. Maree" <jgmaree@******.ac.za>
Subject: SOM and SOMT questionnaires
Date: Wed, 29 Jan 2003 11:13:28 +0200
To: nazir hassan

Dear Sir

Many thanks for your inquiry as well as for the interest shown in the SOM. The questionnaire is available from Dr Jopie van Rooyen and Partners (telephone ******). I have forwarded your message to Dr van Rooyen, who will shortly contact you.
As far as the SOMT is concerned: The questionnaire is still in the process of being developed. Kindly let me know how many students you intend testing and whether you intend conducting factor and item analysis?
Wishing you everything of the best with your studies.
Kind regards
Kobus Maree

Author's note:

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APPENDIX O

EM 2: E-MAIL FROM PROFESSOR K. MAREE - 5 February 2003

Logged in as .. nhassan@****.co.za**
Message in Inbox
From: "Prof. J.G. Maree" <jgmaree@****.ac.za>**
Subject: SOM questionnaire
Date: Wed, 05 Feb 2003 11:26:43 +0200
To: nazir hassan

Dear Nazir

Thank you for your inquiry. A far as your questions are concerned:

- Does the SOM allow one to infer the following: That the items in the SOM allow one to differentiate between DEEP or SURFACE orientation to studies (Use by Marton and Saljo to differentiate between the two types of approaches to study.)

The SOM was not developed to differentiate between those two aspects per se. However, I think it would be most interesting to compare the results of the SOM with the results of similar measuring instruments to see if it does. In other words, may I suggest that you consider administering both the SOM and (e.g.) the Kolb questionnaire/ the Learning Style Pofile/ the MSLQ, or another questionnaire which is more geared towards measuring these aspects?

- That the items of the SOM allow one to infer that the learners' orientations are towards: meaning orientation, reproducing orientation, strategic orientation or/and non-academic orientation (Ramsden, 1992)

The answer is the same as above: Maybe you could administer a questionnaire intended to measure these aspects in conjunction with the SOM?

- None of the above. One has to refer only to the fields of the SOM as set out in the SOM manual.

It would definitely be highly advisable to stick to the fields set out in the manual. Obviously, I suspect high correlations between some of these fields and some of the fields of (say) the Kolb, the MSLQ and the LSP.

Kind regards

Kobus

Author's note:

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APPENDIX P

LETTER TO THE SYSTEM PRE-SERVICE STUDENT TEACHER

The Amalgamated Phatsimang and Perseverance College of Education

Kimberley

Dear Student

I am currently undertaking a research study of the SYSTEM PROJECT (Phase Two: Teacher Training) focussing specifically on your achievements during institutional learning of mathematics and field internship, with special reference to Study orientation in mathematics, Mathematics anxiety and Attitude towards mathematics.

Your valued assistance and cooperation is required in the completion of the four questionnaires.

Student Questionnaire (SQ1): **Attitude Questionnaire.**
Student Questionnaire (SQ2): **Achievement Questionnaire.**
Student Questionnaire (SQ3): **Mathematics Anxiety Questionnaire.**
Student Questionnaire (SQ4): **Study Orientation in Mathematics Questionnaire**

Your co-operation will also be needed for a student-group interview.

Your responses should be as honest as possible, based on your experiences as pre-service students, and will be treated in strict confidence.

With reference to the findings and results of this study, this information could lead to a re-look at the design of teacher-training programmes in mathematics especially from an Outcomes-Based Education perspective and within the ambit Higher Education.

My sincere appreciation to you for your kind assistance.

Yours in Education.

....

N.A.HASSAN

APPENDIX Q

PERMISSION TO CONDUCT INTERVIEWS

DEPARTMENT OF EDUCATION
DEPARTEMENT VAN ONDERWYS
LEFAPHA LA THUTO
ISEBE LEZEMFUNDO
FRANCES BAARD DISTRICT OFFICE

Hayston Road
KIMBERLEY 8301

Private Bag X5041
KIMBERLEY 8300
Republic of South Africa

Tel. (053) 8301600
Fax (053) 8301620

Enquiries: S. REUZANA
Dipatlisiso
Imibuzo
Navrae

Date: [illegible]
Letsatsi
Umhla
Datum

Reference
Tshupelo
Isalathiso
Verwysing

Mr Nazir Hassan
[redacted]
KIMBERLEY
8301

Dear Mr Hassan

RE: PERMISSION TO CONDUCT INTERVIEWS

Permission is hereby granted to you by the District Director to conduct interviews only at the schools mentioned in your correspondence.

I hope you find this matter in order.

Thank you

MR S REUZANA
DISTRICT DIRECTOR

Please visit our Web Site at:
http://[illegible]

5. DATA INFORMATION

APPENDIX R: DATA OF SYSTEM STUDENTS' ACHIEVEMENTS IN MATHEMATICS EXAMINATIONS AND INTERNSHIP TEACHING

APPENDIX S: FREQUENCY SCORES OF THE MA-SOM-T QUESTIONNAIRE

APPENDIX T: FREQUENCY SCORES OF THE MA-MARS QUESTIONNAIRE

APPENDIX U: FREQUENCY SCORES OF THE ATTITUDE QUESTIONNAIRE

APPENDIX R

DATA OF SYSTEM STUDENTS' ACHIEVEMENTS IN MATHEMATICS EXAMINATIONS AND INTERNSHIP TEACHING

Nota Bene: ALL raw scores [*16] reflected below are expressed in percentages.

---

1. **Physical (academic) marks:**

Mathematics I:

Group 1 (n = 10):	56	50	50	51	50	
	50	55	54	67	54	
Group 2 (n = 12):	64	50	50	50	60	61
	57	67	51	61	67	58

Mathematics II:

Group 1 (n = 10):	51	52	57	53	51	
	52	61	54	70	58	
Group 2 (n = 12):	52	55	50	52	54	53
	51	64	52	50	54	69

2. **Internship marks:**

Group 1 (n = 10):	62	60	61	55	55	
	55	59	59	62	58	
Group 2 (n = 12):	59	54	59	63	60	58
	56	60	58	64	64	63

[*16] Raw scores obtained from the College of Education.

APPENDIX S

FREQUENCY SCORES OF THE MA-SOM-T QUESTIONNAIRE

(expressed in %'s to the nearest whole number)

MA-SOM-T item	Group	SOM scale				
		1= Rarely	2= Sometimes	3= Frequently	4= Generally	5= Almost always
SOM1	Group 1	-	20%	30%	30%	20%
	Group 2	-	58%	17%	25%	-
SOM2	Group 1	30%	30%	20%	20%	-
	Group 2	8%	33%	25%	17%	17%
SOM3	Group 1	10%	20%	10%	50%	10%
	Group 2	25%	17%	-	50%	8%
SOM4	Group 1	20%	-	30%	20%	30%
	Group 2	8%	8%	17%	42%	25%
SOM5	Group 1	10%	50%	10%	20%	10%
	Group 2	8%	25%	33%	8%	26%
SOM6	Group 1	10%	30%	30%	20%	10%
	Group 2	-	8%	42%	42%	8%
SOM7	Group 1	10%	20%	10%	20%	40%
	Group 2	-	33%	17%	33%	17%
SOM8	Group 1	10%	20%	10%	40%	20%
	Group 2	8%	25%	-	25%	42%
SOM9	Group 1	-	10%	10%	20%	60%
	Group 2	8%	8%	50%	8%	26%
SOM10	Group 1	56%	22%	-	11%	11%
	Group 2	46%	27%	18%	9%	-
SOM11	Group 1	10%	-	30%	40%	20%
	Group 2	-	17%	8%	25%	50%
SOM12	Group 1	20%	40%	20%	10%	10%
	Group 2	8%	42%	42%	-	8%
SOM13	Group 1	30%	-	10%	40%	20%
	Group 2	8%	34%	42%	8%	8%

MA-SOM-T item	Group	SOM scale				
		1= Rarely	2= Sometimes	3= Frequently	4= Generally	5= Almost always
SOM14	Group 1	40%	40%	-	-	20%
	Group 2	8%	33%	17%	17%	25%
SOM15	Group 1	10%	30%	20%	30%	10%
	Group 2	-	25%	50%	25%	-
SOM16	Group 1	10%	50%	20%	10%	10%
	Group 2	46%	9%	36%	9%	-
SOM17	Group 1	-	30%	20%	20%	30%
	Group 2	-	25%	25%	33%	17%
SOM18	Group 1	-	30%	30%	30%	10%
	Group 2	33%	17%	25%	25%	-
SOM19	Group 1	-	20%	30%	30%	20%
	Group 2	8%	25%	42%	8%	17%
SOM20	Group 1	60%	-	10%	20%	10%
	Group 2	50%	8%	17%	17%	8%

APPENDIX T

FREQUENCY SCORES OF THE MA-MARS QUESTIONNAIRE

(expressed in %'s to the nearest whole number)

MA-MARS item	Group	Anxiety scale			
		1= strongly disagree	2= disagree	3= agree	4= strongly agree
ANX1	Group 1	10%	20%	40%	30%
	Group 2	8%	17%	33%	42%
ANX2	Group 1	40%	30%	30%	-
	Group 2	17%	42%	33%	8%
ANX3	Group 1	10%	20%	40%	30%
	Group 2	8%	25%	42%	25%
ANX4	Group 1	11%	56%	22%	11%
	Group 2	17%	50%	33%	-
ANX5	Group 1	20%	-	50%	30%
	Group 2	-	8%	50%	42%
ANX6	Group 1	30%	50%	10%	10%
	Group 2	25%	41%	17%	17%
ANX7	Group 1	10%	50%	40%	-
	Group 2	50%	33%	17%	-
ANX8	Group 1	30%	50%	10%	10%
	Group 2	42%	33%	25%	-
ANX9	Group 1	10%	20%	50%	20%
	Group 2	-	58%	25%	17%
ANX10	Group 1	10%	50%	30%	10%
	Group 2	25%	50%	17%	8%
ANX11	Group 1	10%	20%	40%	30%
	Group 2	8%	25%	67%	-
ANX12	Group 1	-	20%	40%	40%
	Group 2	8%	8%	8%	76%
ANX13	Group 1	-	40%	20%	40%
	Group 2	17%	33%	33%	17%

MA-MARS item	Group	Anxiety scale			
		1= strongly disagree	2= disagree	3= agree	4= strongly agree
ANX14	Group 1	20%	20%	50%	10%
	Group 2	8%	42%	25%	25%
ANX15	Group 1	-	20%	70%	10%
	Group 2	17%	17%	41%	25%
ANX16	Group 1	-	40%	40%	20%
	Group 2	-	33%	33%	34%
ANX17	Group 1	-	30%	60%	10%
	Group 2	33%	25%	42%	-
ANX18	Group 1	20%	60%	20%	-
	Group 2	33%	50%	17%	-
ANX19	Group 1	10%	80%	10%	-
	Group 2	33%	33%	34%	-
ANX20	Group 1	40%	30%	30%	-
	Group 2	67%	33%	-	-

APPENDIX U

FREQUENCY SCORES OF THE ATTITUDE QUESTIONNAIRE

(expressed in %'s to the nearest whole number)

Attitude item	Group	Attitude scale			
		1= strongly disagree	2= disagree	3= agree	4= strongly agree
ATT1	Group 1	-	-	50%	50%
	Group 2	-	25%	50%	25%
ATT2	Group 1	10%	50%	30%	10%
	Group 2	9%	25%	33%	33%
ATT3	Group 1	-	20%	30%	50%
	Group 2	17%	25%	25%	33%
ATT4	Group 1	-	10%	60%	30%
	Group 2	-	-	33%	67%
ATT5	Group 1	30%	-	40%	30%
	Group 2	42%	17%	25%	16%
ATT6	Group 1	-	10%	60%	30%
	Group 2	-	25%	58%	17%
ATT7	Group 1	30%	10%	40%	20%
	Group 2	-	42%	50%	8%
ATT8	Group 1	30%	30%	30%	10%
	Group 2	17%	33%	8%	42%
ATT9	Group 1	10%	20%	10%	60%
	Group 2	25%	25%	25%	25%
ATT10	Group 1	-	-	70%	30%
	Group 2	8%	17%	50%	25%