

M Ed (Tertiary Teaching Package)

## EDUC 7031 Research Report

An initial analysis of the progress of the first cohort of the Targeting Talent Program (TTP) students at the University of the Witwatersrand in 2010

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An initial analysis of the progress of the first cohort of the  
Targeting Talent Program (TTP) students at the University  
of the Witwatersrand in 2010

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A research report submitted to the Wits School of Education, Faculty of  
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## **Abstract**

In 2007, the Student Equity and Talent Management Unit (SETMU) at the University of the Witwatersrand (Wits) initiated a programme called the Targeting Talent Programme (TTP). One of the objectives of the TTP is to equip students to be successful at university. The first cohort of students consisted of 270 talented Grade 9 students from disadvantaged rural and urban schools. They were identified at the end of 2006, and they attended enrichment sessions at the University during 2007, 2008 and 2009. Thirty seven of the students enrolled for Engineering at Wits in 2010. They were given no further assistance by the TTP.

The TTP based the planning of its curriculum on the Competencies identified by the Programme for International Student Assessment (PISA). The primary aim of the PISA assessment is to determine the extent to which young people have acquired the wider knowledge and skills in reading, mathematical and scientific literacy that they will need in adult life, hence the TTP attempted to incorporate the PISA Competencies in their curriculum in order to equip students for tertiary education. Habits of Mind identified by Cuoco and others were also used in planning the TTP curriculum in order to equip students with thinking skills.

The TTP was successful in helping students to achieve university entrance, but there is a need to investigate to what extent the three year intervention program enables the students to succeed at university. This report focuses on the 37 students who enrolled for Engineering at Wits in 2010. They are compared to a sample of 37 students from the 2010 cohort who did not attend the TTP. The sample of non-TTP students was chosen by matching the National Senior Certificate Mathematics and Science marks obtained by the ex-TTP students as closely as possible. Thus two samples with an almost identical initial academic profile were created. One of the differences between the samples is that the ex-TTP students had had input which was aimed at equipping them to attain university entrance and to succeed there, whereas the other students had had no such formal assistance. The ex-TTP students were also compared with the cohort as a whole.

This report shows that 16 of the 37 students (43%) passed the Mathematics, Mechanics and Physics courses that they were enrolled for. It also shows that the ex-TTP students scored lower on average than the non-TTP students and the cohort, for the Mathematics, Physics and Mechanics courses that they were enrolled for. Interviews with 9 of the ex-TTP students show that they did not consciously transfer study techniques from the TTP to university. The TTP was thus only partially successful in its objective of enabling students to be successful at university.

## **Keywords**

Targeting Talent Programme; habits of mind; mathematical competencies; scientific competencies; PISA; enrichment programmes, study techniques and academic proficiency.

## **Declaration**

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Education at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signed: .....

Anne Rosemary Tyldesley Gray

\_\_\_\_\_ day of \_\_\_\_\_ in the year \_\_\_\_\_

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## **Chapter 1: Introduction**

### **1.1 The Research Question**

This Research Report is an initial analysis of the progress of the first cohort of the Targeting Talent Program (TTP) students at the University of the Witwatersrand. It focuses on the Engineering students who completed their first year at the end of 2010, and thus the over-arching research question is:

To what extent have the ex-TTP students succeeded in their first year of the Engineering degrees for which they are registered?

### **1.2 Background to the Targeting Talent Programme**

The Targeting Talent Programme is an initiative of the Equity Division at the University of the Witwatersrand. It was implemented in response to two main needs. Firstly, the need to increase access to university education for young adults from schools where tertiary education is not usually an achievable objective, and secondly the need for more graduates in Engineering and the Sciences.

The TTP is implemented when carefully selected students from rural and urban, under-resourced, under-performing schools are in Grade 10. The students are part of the programme through to the end of Grade 12.

From the Targeting Talent Programme Executive Summary (2007):

*The goal of the Targeting Talent programme is to implement a targeted enrichment and support programme that will identify and eventually recruit academically excellent or high potential black learners from under-resourced schools. It addresses the critical shortages in the output from schools of matriculants who are ready to enter science, engineering and technology-oriented (SET) programmes at universities like Wits. Presently, less than 15% of school-leavers enter the higher education system, and half of these leave the*

*system again without a qualification. The single biggest factor preventing learners from entering higher education, or preventing them from succeeding if they do manage to enter, is academic preparedness. While other factors (like the financial status of families, or subject choice) do play a role, it is the level of competency in key subjects, and orientations toward study, that influence the success of learners most directly. Exacerbating this problem is the fact that universities tend to draw from a limited pool of (mostly urban) feeder schools, failing to draw on the talent and potential that lies in the fuller population.*

*The Targeting Talent Programme at Wits addresses these issues by identifying talented learners from a broader range of under-resourced schools and providing them with a three-year pre-university programme of additional tuition in an enrichment curriculum calculated to prepare learners to access and succeed in SET programmes at any university in the country. The selection process into the programme is designed rigorously to identify exceptional learners. Part of the programme includes an annual two-week on-campus residential curriculum. This involves deep-immersion tuition by top quality university lecturers and exposure to academic and student role models from SET fields of study. Further, the programme provides support for the teachers of the learners enrolled in the programme, to ensure continuity and mentoring of the cohort. (p.1).*

### **1.3 Rationale for the Study**

There are two reasons for implementing this study. Firstly, in 2010 the first cohort of TTP students were accepted into universities, some of them at Wits, and it is important to characterise the achievements of this cohort in order to inform the various stakeholders in the TTP. Secondly, a design is needed for the full evaluation of whether the aims of the TTP have been achieved.

The first three years of the TTP has enabled 219 students of a cohort of 270, to pass the NSC with matriculation exemption and of those, 45 gained access to Engineering at Wits. (Targeting Talent Tracking Document, 2009). These students attended under-resourced rural and urban schools and would not necessarily have achieved matriculation exemptions, and probably would not have developed the academic

attributes that are necessary for success in tertiary education without the interventions provided by the TTP. Having invested much time, effort and money in the program, the sponsors, the university and all the people involved with the design and execution of the programme need to know if it has succeeded in both of its aims of not only access to, but success in, tertiary SET education.

The design and methodology of this study has been conceptualised to be an initial attempt at a design and methodology that could be used in the formal longitudinal evaluation of the TTP. Due to the constraints of this being a Research Report, there are many limitations to, and short-comings of this study that should be addressed by a more thorough study.

#### **1.4 The Samples of Students**

After considering several options, it was decided that only the TTP students registered for Engineering would be studied because the author is familiar with the course material of the first year of the Engineering degree and knows many of the lecturers in Mathematics and Physics. The author decided to match the ex-TTP students with students who had not been part of the Programme. These students will be referred to as non-TTP students. The non-TTP students were chosen from those who had similar academic characteristics on entrance to Wits as the ex-TTP students did. This was done in order to see if students who started with similar academic achievements had ended the year with similar academic achievements. It was also decided to compare the ex-TTP students with the entire cohort of first year Engineering students.

Of the initial 45 ex-TTP students who enrolled for Engineering at Wits in 2010, 37 remained in the class until the end of the year. These 37 students were matched with a sample of 37 non-TTP students with the following academic characteristics:

- The students have the same number of Wits Points<sup>1</sup>
- The students have the same, or similar, NSC Mathematics and Physical Science marks.

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<sup>1</sup> Wits Points are calculated from a student's NSC results. See Appendix 1.

## 1.5 The Subject Areas

Due to the constraints on the length and depth of the study imposed by the nature of a Research Report, only the Mathematics, Physics and Mechanics marks attained by the students are considered. For this reason, only the NSC Mathematics and Physical Science marks were used in choosing the sample of non-TTP students. The Mathematics course and the first semester of the Mechanics course are taken by the students in all branches of Engineering. Mathematics is a full course, ie it is two semesters long. In the second semester, Mechanics is taken by all branches except the Chemical and Metallurgical and Materials branches. Physics is a full course also taken by all except the Chemical and Metallurgical and Materials branches.

Mathematics and physics, of which mechanics is a component, are considered to constitute a vital part of the initial education of an engineer. Mathematics, in particular, is regarded as the “language” of Engineering (Dym, 2003, p.146). Physics is a course common to all branches of Engineering at Wits, and is regarded as of foundational importance for many other courses encountered in the later years of the Engineering degrees. This is shown by the following comment from the Physics IE Course Outline (School of Physics, 2010a): “The Engineering Council of South Africa (ECSA) is emphatic that an engineering graduate should have a solid grounding in basic physical, mathematical and engineering principles...”. (p.1). Success in mathematics and physics at the first year level is taken to indicate the presence of the aptitudes necessary for future success in Engineering.

## 1.6 Competencies and Habits of Mind

Several authors (e.g. Dym, 2003; Dym et al, 2001; Felder et al, 2000; Redish and Smith, 2008; and Woods et al, 2000) are of the opinion that there are many issues affecting success at university. Given that the only tangible measure of success that is used by Wits University (and most other universities) is the marks that students achieve in tests and examinations, it was decided, in this study, to focus not only on the ex-TTP students’ academic achievements as a measure of their success at Wits, but also on asking the students if they were consciously using the knowledge and skills that they had gained from the TTP while studying at Wits. The TTP teachers were (and are) trying to embed Competencies and Habits of Mind during contact time with the students. These attributes are intended to become the tools that are utilized by

the students in their university work.

Blomhøj (2007) remarks that “Competence is someone’s insightful readiness to act in response to the challenges of a given situation.” (p.3).

Lim and Seldon (2009) use a reference to Driscoll (1999) where [he] “views habits of mind as ways of thinking that, when used habitually, can lead to successful learning of algebra.” (p.1579).

Competencies and Habits of Mind are similar to what Woods et al (2000) call process skills. They say “*Process skills* are ‘soft’ skills used in the application of knowledge. The degree to which students develop these skills determines how they solve problems, write reports, function in teams, self-assess and do performance reviews of others, go about learning new knowledge, and manage stress when they have to cope with change.” (p.1).

## 1.7 Study Techniques

While at school, TTP students are encouraged to study in groups and to study together outside of school hours. I decided to investigate whether the ex-TTP students were using study groups of their own making or were using other study techniques in order to maximise their achievements. In the following quote, Felder and Brent (2003) are referring to organised groups in a class situation, but the remarks apply well to informal groups that study together:

*A large and rapidly growing body of research confirms the effectiveness of cooperative learning in higher education* <sup>[43, 80, 83]</sup>. *Relative to students taught traditionally - i.e., with instructor-centered lectures, individual assignments, and competitive grading - cooperatively taught students tend to exhibit higher academic achievement, greater persistence through graduation, better high-level reasoning and critical thinking skills, deeper understanding of learned material, lower levels of anxiety and stress, more positive and supportive relationships with peers, more positive attitudes toward subject areas, and higher self-esteem. (p.15).*<sup>2</sup>

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<sup>2</sup> Superscript numbers in square brackets refer to references in the original article.

## **1.8 Research Design**

When considered from the three perspectives of academic proficiency, Competencies and Habits of Mind, and study techniques, the over-arching research question resolved itself into three foci, namely: Focus A: Academic Proficiency; Focus B: Mathematical and Scientific Competencies and Habits of Mind associated with academic proficiency; and Focus C: Study Techniques.

### **1.8.1 Focus A: Academic Proficiency**

Felder et al (2000) summarise their goals in teaching engineering students with the statement that: “Our goal in teaching is to get information and skills encoded in our students’ long-term memories. Cognitive research tells us that people learn new material contextually, fitting it into existing cognitive structures,<sup>[13-15]</sup> and new information that cannot be linked to existing knowledge is not likely to be retained. Moreover, once information is stored in long-term memory, cues are required for us to recall and use it.” (p.5).<sup>3</sup> Questions in tests and examinations are one form of cue that provokes recall of information.

Focus A will show how successful the ex-TTP students have been at using tests and examinations to display the knowledge they have acquired in Mathematics, Physics and Mechanics. Comparisons of marks will be done in several ways in order to tease out a description of the nature and magnitude of the academic success of the ex-TTP students.

### **1.8.2 Focus B: Mathematical and Scientific Competencies and Habits of Mind associated with academic proficiency**

The intention of this focus is to show that there are Competencies and Habits of Mind present in the teaching material accessible to students, and that they are intended to be passed on to students. Documents and interviews with TTP teachers will be used to identify Competencies and Habits of Mind present in the TTP. The TTP has used the PISA document (OECD, 2006) to construct its curriculum framework, so Competencies and Habits of Mind should be consciously present in the materials used by the TTP and in the minds of the TTP teachers. The Schools of Mathematics and Physics at Wits do not use a curriculum framework based on the PISA document or any other document of the same nature, so if Competencies and Habits of Mind are

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<sup>3</sup> Superscript numbers in square brackets refer to references in the original article.

being passed on to students at Wits, it is not being done as a result of the type of curriculum being used. An analysis of Wits teaching material and interviews with Wits lecturers will show the extent to which Competencies and Habits of Mind are present.

### **1.8.3 Focus C: Study Techniques**

The TTP aims to prepare students to be successful on their own when they are at university. The study techniques that are actually used by the students will give an insight into what they have transferred from the TTP to the university scenario, and will illuminate the academic proficiency attained by the students.

## **1.9 Outline of the Remaining Chapters**

Chapter 2 is a review of the literature pertinent to this study. Chapter 3 will expand on the research design and methodology used in the field work. Chapters 4, 5 and 6 will present and discuss the results obtained in each of the Foci. Chapter 7 will show conclusions and recommendations.

## **Chapter 2:       Review of Literature Pertinent to Each                           Focus Area**

### **2.1    Focus A: Academic Proficiency**

The aims of the TTP are to enable students to gain entry to tertiary education in the SET arena and to succeed at tertiary level. Many authors in the Engineering Education arena identify academic preparedness as one of the major stumbling blocks for students entering first year engineering, e.g . Fitzgerald, 2004, Felder *et al*, 2000. The TTP has attempted to give students “mathematical competencies” (Niss, 2002) and “habits of mind” (Cuoco et al, 1996) which can be applied to almost any form of teaching and thus learning should be taking place if the intervention has been successful. For the purposes of this study, “Academic Proficiency” will be taken to be the actual marks that students achieve in tests and examinations, as well as how students’ achievements compare with others, i.e. their ranking relative to the whole cohort in first-year Engineering.

Knowledge *about* a subject is seen as being essential in Engineering, but there is an increasing awareness that there are skills and other attributes that learners acquire that enable them to access the knowledge of *how to apply* the knowledge *about* a subject. (Dym, 2003; Redish and Smith, 2008; Shuman et al, 2005). However, judging “how well” a student has done academically is still very much confined to looking at marks and making a judgement. This study will attempt to indicate “how well” the ex-TTP students have fared in relation to criteria for passing tests and examinations, and to indicate “how well” they have done in relation to other students who have not had the TTP experience.

Assessment is a thorny issue, but at Wits and at most other universities, progression to the next levels of the Engineering degree is determined by obtaining a passing Final

Mark in each subject (Rules and Syllabus Book, 2010; Stevens et al, 2008, p.357).

## **2.2 Focus B: Mathematical and Scientific Competencies and Habits of Mind associated with academic proficiency**

Mathematical and Scientific Competencies (Niss, 2002) and Habits of Mind (Cuoco, 1996) can be regarded as two sides of the same coin. Both notions focus on what the learner does with the subject material, and both are attributes which are both general to many subjects and specific to particular subjects. Both authors advocate that curricula should be designed so that the subject material fosters the thinking skills and the thinking skills foster in-depth understanding and knowledge of the subject material. Cuoco et al (1996) are particularly clear about this:

*A curriculum organised around habits of mind tries to close the gap between what the users and makers of mathematics do and what they say. Such a curriculum lets students in on the process of creating, inventing, conjecturing, and experimenting; it lets them experience what goes on behind the study door before new results are polished and presented. It is a curriculum that encourages false starts, calculations, experiments, and special cases. Students develop the habit of reducing things to lemmas for which they have no proofs, suspending work on these lemmas and on other details until they see if assuming the lemmas will help. It helps students look for logical and heuristic connections between new ideas and old ones. A habits of mind curriculum is devoted to giving students a genuine research experience. (p.376).*

Niss (2002) has identified eight competencies which he divides into two groups: the first four competencies “are to do with the ability to *ask and answer questions in and with mathematics*” (p.7) and the second four competencies “are to do with the ability to deal with and *manage mathematical language and tools*” (p.8). The eight competencies are:

1. *Thinking mathematically* (mastering mathematical modes of thought)
2. *Posing and solving mathematical problems*
3. *Modelling mathematically* (i.e., analyzing and building models)
4. *Reasoning mathematically*
5. *Representing mathematical entities*

6. *Handling mathematical symbols and formalisms*
7. *Communicating in, with, and about mathematics*
8. *Making use of aids and tools (including information technology)*

Niss (2002) elaborates on each of these competencies. The full version of the text makes clear the links to the required mathematical skills mentioned by Ridley (2001) and to the problem solving abilities expected of students in Physics.

The PISA document (OECD, 2006) uses the competencies identified by Niss, but orders them slightly differently, viz:

- *Thinking and reasoning*: this involves posing questions characteristic of mathematics (“Is there...?”, “If so, how many?”, “How do I find...?”); knowing the kinds of answers that mathematics offers to such questions; distinguishing between different kinds of statements (definitions, theorems, conjectures, hypotheses, examples, conditioned assertions); and understanding and handling the extent and limits of given mathematical concepts.
- *Argumentation*: this involves knowing what mathematical proofs are and how they differ from other kinds of mathematical reasoning; following and assessing chains of mathematical arguments of different types; possessing a feel for heuristics (“What can or cannot happen, and why?”); and creating and expressing mathematical arguments.
- *Communication*: this involves expressing oneself, in a variety of ways, on matters with a mathematical content, in oral as well as in written form, and understanding others’ written or oral statements about such matters.
- *Modelling*: this involves structuring the field or situation to be modelled; translating reality into mathematical structures; interpreting mathematical models in terms of reality; working with a mathematical model; validating the model; reflecting, analysing and offering a critique of a model and its results; communicating about the model and its results (including the limitations of such results); and monitoring and controlling the modelling process.
- *Problem posing and solving*: this involves posing, formulating and defining different kinds of mathematical problems (for example “pure”,

“applied”, “open ended” and “closed”), and solving different kinds of mathematical problems in a variety of ways.

- *Representation*: this involves decoding and encoding, translating, interpreting and distinguishing between different forms of representation of mathematical objects and situations; the interrelationships between the various representations; and choosing and switching between different forms of representation, according to situation and purpose.
- *Using symbolic, formal and technical language and operations*: this involves decoding and interpreting symbolic and formal language, and understanding its relationship to natural language; translating from natural language to symbolic/formal language; handling statements and expressions containing symbols and formulae; and using variables, solving equations and undertaking calculations.
- *Use of aids and tools*: this involves knowing about, and being able to make use of, various aids and tools (including information technology tools) that may assist mathematical activity and knowing about the limitations of such aids and tools. (p.97).

The PISA document identifies three types of cognitive demands that are needed to solve different mathematical problems. They are: reproduction of practised knowledge, solving non-routine problems but within a familiar or quasi-familiar setting, and reflection which enables the solution of unfamiliar problems. The eight competencies are explained relative to each of these three cognitive demands. The cognitive demands are designated as competency clusters. Table 1 (starting on page 12) shows how each of the eight competencies is characterised in each cluster. The table was prepared by tabulating the list of information given in the PISA document on pages 98 to 101.

**Table 1 Characteristics of Competencies**

| Competency             | Reproduction Cluster  | Connections Cluster   | Reflection Cluster  |
|------------------------|---|---|---|
| Thinking and reasoning | This involves posing the most basic forms of questions (“How many...?”, “How much is...?”) and understanding the corresponding kinds of answers (“so many...”, “this much...”); distinguishing between definitions and assertions; understanding and handling mathematical concepts in the sorts of contexts in which they were first introduced or have subsequently been practised. | This involves posing questions (“How do I find...?”, “Which mathematics is involved...?”) and understanding the corresponding kinds of answers (provided by means of tables, graphs, algebra, figures, etc.); distinguishing between definitions and assertions and between different kinds of assertions; and understanding and handling mathematical concepts in contexts that are slightly different from those in which they were first introduced or have subsequently been practised. | This involves posing questions (“How do I find...?”, “Which mathematics is involved...?”, “What are the essential aspects of the problem or situation...?”) and understanding the corresponding kinds of answers ( provided by tables, graphs, algebra, figures, specification of key points etc.); distinguishing between definitions, theorems, conjectures, hypotheses and assertions about special cases, and reflecting upon or actively articulating these distinctions; understanding and handling mathematical concepts in contexts that are new or complex; and understanding and handling the extent and limits of given mathematical concepts, and generalising results. |

| Competency    | Reproduction Cluster   | Connections Cluster   | Reflection Cluster  |
|---------------|--|---|---|
| Argumentation | This involves following and justifying standard quantitative processes, including computational processes, statements and results.   | This involves simple mathematical reasoning without distinguishing between proofs and broader forms of argument and reasoning; following and assessing chains of mathematical arguments of different types; and possessing a feel for heuristics ( <i>e.g.</i> “What can or cannot happen, or be the case, and why?”, “What do I know and what do I want to obtain?”).                                | This involves simple mathematical reasoning, including distinguishing between proving and proofs and broader forms of argument and reasoning; following, assessing and constructing chains of mathematical arguments of different types; and using heuristics ( <i>e.g.</i> “What can or cannot happen, or be the case, and why?”, “What do I know, and what do I want to obtain?”, “Which properties are essential?”, “How are the objects related?”). |
| Communication | This involves understanding and expressing oneself orally and in writing about simple mathematical matters, such as reproducing the names and the basic properties of familiar objects, citing computations and their results, usually not in more than one way. | This involves understanding and expressing oneself orally and in writing about mathematical matters ranging from reproducing the names and basic properties of familiar objects and explaining computations and their results (usually in more than one way), to explaining matters that include relationships. It also involves understanding others’ written or oral statements about such matters. | This involves understanding and expressing oneself orally and in writing about mathematical matters ranging from reproducing the names and basic properties of familiar objects, and explaining computations and their results (usually in more than one way), to explaining matters that include complex relationships, including logical relationships. It also involves understanding others’ written or oral statements about such matters.         |

| Competency                 | Reproduction Cluster   | Connections Cluster  | Reflection Cluster   |
|----------------------------|--|--|--|
| Modelling                  | This involves recognising, recollecting, activating and exploiting well-structured, familiar models; interpreting back and forth between such models (and their results) and reality; and elementary communication about model results.                  | This involves structuring the field or situation to be modelled; translating reality into mathematical structures in contexts that are not too complex but nevertheless different from what students are usually familiar with. It involves also interpreting back and forth between models (and their results) and reality, including aspects of communication about model results. | This involves structuring the field or situation to be modelled; translating reality into mathematical structures in contexts that may be complex or largely different from what students are usually familiar with; interpreting back and forth between models (and their results) and reality, including aspects of communication about model results: gathering information and data, monitoring the modelling process and validating the resulting model. It also includes reflecting through analysing, offering a critique, and engaging in more complex communication about models and modelling. |
| Problem posing and solving | This involves posing and formulating problems by recognising and reproducing practised standard pure and applied problems in closed form; and solving such problems by invoking and using standard approaches and procedures, typically in one way only. | This involves posing and formulating problems beyond the reproduction of practised standard pure and applied problems in closed form and solving such problems by invoking and using standard approaches and procedures, as well as more independent problem solving processes in which connections are made between different mathematical areas and                                | This involves posing and formulating problems well beyond the reproduction of practised standard pure and applied problems in closed form; solving such problems by invoking and using standard approaches and procedures, but also more original problem solving processes in which   |

|  |  |  |  |
|--|--|--|--|
|  |  | modes of representation and communication (schemata, tables, graphs, words, pictures).   | connections are being made between different mathematical areas and modes of representation and communication (schemata, tables, graphs, words, pictures). It also involves reflecting on strategies and solutions.  |
| Competency   | Reproduction Cluster   | Connections Cluster  | Reflection Cluster   |
| Representation   | This involves decoding, encoding and interpreting familiar, practised standard representations of well known mathematical objects. Switching between representations is involved only when the switching itself is an established part of the representations implied. | This involves decoding, encoding and interpreting familiar and less familiar representations of mathematical objects; choosing and switching between different forms of representation of mathematical objects and situations; and translating and distinguishing between different forms of representation. | This involves decoding, encoding and interpreting familiar and less familiar representations of mathematical objects; choosing and switching between different forms of representation of mathematical objects and situations, and translating and distinguishing between different forms of representation. It further involves the creative combination of representations and the invention of non-standard ones. |
| Using symbolic, formal and technical language and operations | This involves decoding and interpreting routine basic symbolic and formal language practised in well known contexts and situations; and handling simple statements and expressions containing  | This involves decoding and interpreting basic symbolic and formal language in less well-known contexts and situations, and handling statements and expressions containing symbols and formulae, including using variables, solving equations and undertaking   | This involves decoding and interpreting symbolic and formal language practised in unknown contexts and situations, and handling statements and expressions containing symbols and formulae, including using  |

|                       |  |   |   |
|-----------------------|--|---|---|
|                       | symbols and formulae, including using variables, solving equations and undertaking calculations by routine procedures.   | calculations by familiar procedures.  | variables, solving equations and undertaking calculations. It also involves the ability to deal with complex statements and expressions and with unfamiliar symbolic or formal language, and to understand and to translate between such language and natural language. |
| Competency            | Reproduction Cluster   | Connections Cluster   | Reflection Cluster  |
| Use of aids and tools | This involves knowing about and being able to use familiar aids and tools in contexts, situations and ways close to those in which their use was introduced and practised. | This involves knowing about and using familiar aids and tools in contexts, situations and ways that are different from those in which their use was introduced and practised. | This involves knowing about and using familiar or unfamiliar aids and tools in contexts, situations and ways that are quite different from those in which their use was introduced and practised. It also involves knowing about limitations of aids and tools.         |

The National Curriculum Statement for South Africa (Mathematics) (DoE, 2003a) has clear attributes that are ideally desired for learners who exit from the FET band (see Table 2, p.18). It can be seen that the competencies identified by Niss (2002) are present amongst the attributes that are desired for such learners. Thus, the school curriculum is designed so that successful learners will acquire many of the competencies needed for success at tertiary level.

Lim (2010) has summarised some general habits of mind and some specific habits of mind that are pertinent to the present investigation (See Table 3, p.19). A careful reading of the DoE National Curriculum Statements for Mathematics and Physical Science (DoE, 2003a and 2003b) shows that many of these Habits of Mind are evident in the descriptions of the Critical Outcomes, the Developmental Outcomes, the type of learner envisaged, (DoE, 2003a and b, p.2) and in the Purpose and Scope for the subjects. (DoE, 2003a and b, p.10). The TTP interventions were designed to emphasise the skills and attributes that are present in the school curriculum precisely because the conditions prevailing in their classrooms militate against the acquisition of these attributes and skills by the students.

In the First Year Engineering Mathematics notes (used by the students at Wits) Ridley claims that “...understanding the principles and facility with the techniques are of prime importance.” (Ridley, 2001, p.iii). There is no mention of ways to understand the principles or suggestions for becoming familiar with the techniques, but the requirement for students to have the combination of a knowledge base and skills is present. The course outline of the Engineering Physics course has a strong emphasis on knowing the basic facts and developing appropriate problem solving approaches. (School of Physics, 2010a). Students who exercise the Habits of Mind identified by Cuoco et al (1996) and Costa and Kallick (2000) (See Table 3 pg 19.) would have the tools for knowing the facts and for using the techniques required of them by the Mathematics and Physics courses.

**Table 2**      **Attributes of Learners Exiting the FET Band** (DoE, 2003, p.10)**SCOPE**

Learners in the FET band who are interested in the subject or who intend to follow a career path requiring Mathematics will, while ensuring that they are mathematically literate, work towards being able to:

- competently use mathematical process skills such as making conjectures, proving assertions and modelling situations;
- calculate confidently and competently with and without calculators, and use rational and irrational numbers with understanding;
- competently produce useful equivalents for algebraic expressions, and use such equivalents appropriately and with confidence;
- use mathematics to critically investigate and monitor the financial aspects of personal and community life;
- use mathematics to critique arguments on which political decisions are based;
- work with a wide range of patterns and transformations (translations, rotations, reflections) and solve related problems;
- describe, represent and analyse shape and space in two and three-dimensions using geometry and trigonometry;
- collect and use data to establish basic statistical and probability models, solve related problems and critically consider representations provided or conclusions reached;
- use and understand the principles of the differential calculus to determine the rate of change of a range of simple, non-linear functions and solve optimisation problems;
- solve problems involving sequences and series in real life and mathematical situations; and
- use available technology in calculations and in the development of mathematical models.

**Table 3 Habits of Mind (Lim, 2010)**

|  |
|--|
| <b>Characteristics of general habits of minds (Cuoco, Goldenberg, &amp; Mark, 1996)</b>  |
| Students should be:<br>Pattern sniffers, Experimenters, Describers, Thinkers, Inventors, Visualizers, Conjecturers, Guessers   |
| <b>Habits of mind specific to mathematics (Cuoco, Goldenberg, &amp; Mark, 1996)</b>  |
| Talk big and think small (from the general to the specific)<br>Talk small and think big (from the specific to the general)<br>Use functions<br>Use multiple points of view<br>Mix deduction and experiment<br>Push the language<br>Use intellectual chants   |
| <b>Algebraic approaches to things</b><br>a. like a good calculation    d. break things into parts<br>b. use abstraction            e. extend things<br>c. use algorithms              f. represent things  |
| <b>Geometric approaches to things</b><br>a. use proportional reasoning    e. worry about things that change<br>b. use several languages at once    f. worry about things that do not change<br>c. use one language for everything    g. love shapes<br>d. love systems   |
| <b>Cross-disciplinary General Habits of Mind (Costa, 2000)</b>   |
| Persisting; Managing impulsivity; Listening with understanding and empathy;<br>Thinking flexibly; Thinking about thinking (metacognition); Striving for accuracy;<br>Questioning and posing problems; Applying past knowledge to new situations;<br>Thinking and communicating with clarity and precision; Gathering data through all senses;<br>Creating, imagining, innovating; Responding with wonderment and awe;<br>Taking responsible risks; Finding humour; Thinking interdependently; Remaining open to continuous learning. |

### **2.3 Focus C: Study techniques as one of many variables intended to ensure academic proficiency**

The TTP encouraged the development of Habits of Mind and Competencies so that these could be used when students were left to work on their own between contacts with facilitators. At each targeted school, there was always more than one student chosen to participate in the TTP. This ensured that students could study together. (Targeting Talent Programme Tracking Document, 2009)

Developing Habits of Mind and Competencies can be seen as a specialisation of the Constructivist learning theory: learners construct their individual mental images and understandings of learning material by building on and adapting what they already know. Davis (2004) points out that “Constructivists have repeatedly acknowledged that the individual is not free to construct the world in whatever way he or she pleases. Personal interpretations are subject to constraints of physical experience, the associations built into language, and so on. The point is not that the individual is free to construct any world, but that the individual is compelled to construe a reality that fits with the context or circumstance.” (pp. 120-121).

There is much evidence in Education literature that student learning is motivated by what is required by examiners, e.g. Brown, 2001; Felder and Brent, 2003. Students have a variety of methods that they use for getting to grips with what they need to know for tests and examinations, such as rote learning, practising past papers, working in study groups, going to tutors (who could be post-graduate students), and attending Academic Support classes. Because efficient coping mechanisms contribute to success in tests and examinations, this study will try to obtain some evidence from students about how they cope with the demands made by the assessments they are subjected to.

## **Chapter 3: Research Design and Methodology**

### **3.1 Introduction**

The data for the first two foci of this report are empirical and post-hoc, using existing numerical data and textual data. The data for the third focus is post-hoc descriptive, using data generated from interviews. The study is aimed at assessing the extent to which the 37 ex-TTP students enrolled in first year Engineering at Wits achieved academic proficiency. Secondly, it will show that the Competencies and Habits of Mind initially planned for were in fact present in the TTP curriculum. It will also show that the same Competencies and Habits of Mind that were consciously incorporated into the TTP curriculum are covertly present in the teaching techniques and teaching material used by the Wits Mathematics, Mechanics and Physics lecturers. Lastly, it will describe the study techniques for tests and examinations that 9 of the 37 ex-TTP students used.

### **3.2 Ethics Clearance**

Ethics clearance was obtained from the Wits School of Education to access student's marks and to interview students. The Protocol Number is 2010ECE172C. Students signed documents giving permission to access their marks and to interview them. Permission to access test and examination marks was also obtained from the Heads of School of Mathematics and Physics. The Heads of School required that I undertook not to release information to the public and that individual students were not identified in my report.

### **3.3 Samples**

The sample of ex-TTP students was simply all the ex-TTP students who were still in the first year Engineering class in the fourth teaching block of 2010. The sample of non-TTP students was chosen from the rest of the first year Engineering class of

2010.

In the fourth teaching block there were 37 ex-TTP students in the first year Engineering class of 2010 and thus a sample of 37 non-TTP students from the same class was chosen. The non-TTP students were chosen by matching each ex-TTP student with a non-TTP student with the same number of Wits points<sup>4</sup> and identical or similar NSC marks in Mathematics and Physical Science. The sampling was done with the intention of identifying students with the same official academic results from school, but with one sample having had the experience of the TTP, and the other not having had the same experience, and then looking at whether the students' academic results had diverged by the time they wrote the final examinations at the end of first year.

The whole cohort of engineers takes MATH1014 Mathematics. The Biomedical, Civil, Electrical, Mechanical, Aeronautical, Industrial and Mining branches take PHYS1014 Physics IE, a full course in physics, and PHYS1015 Applied Mechanics, which is a full course in mechanics. The other two branches, the Chemical branch and Metallurgy and Materials branch, take CHMT1001 Applied Mechanics. CHMT1001 is the same as the first semester of PHYS1015. The students write the same tests and the same examination in June. Thus the whole cohort does the first semester of mechanics together. PHYS1014 will be referred to as "Physics", CHMT1001 and the first semester of PHYS1015 will be referred to as "Mechanics I", the full course PHYS1015 will be referred to as "Mechanics II".

When the sampling was done, the students were not matched by gender or race or social background or by branch of engineering for which they had registered. This is possibly a weakness in the sampling design because all these factors could have influenced the academic results obtained by the non-TTP students. Also, the sub-samples that take Physics and Mechanics II do not consist entirely of matched pairs. There were 20 ex-TTP students and 26 non-TTP students in the Physics and Mechanics II samples.

Ethics clearance and other administrative processes took so long that by the time it was possible to arrange interviews with students, the teaching year had ended and

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<sup>4</sup> These are points calculated by Wits using the student's NSC results. See Appendix 1.

students were studying for examinations. Only 9 of the ex-TTP students volunteered to be interviewed, although all 37 of them were willing to be interviewed when they were asked to sign consent forms earlier in the year. The 9 volunteers are thus not a representative sample of the 37 ex-TTP students. None of the non-TTP students were available for interviews.

The Mathematics, Science and Molecular Literacy TTP teachers who had been teaching the cohort of ex-TTP students from 2007 were interviewed. Two Mathematics and one Physics lecturer from Wits were interviewed. They were all lecturers for the first year Engineering class.

### **3.4 Research Questions**

The following questions were used to gather data in each of the three Focus areas.

#### **3.4.1 Focus A: Academic Proficiency**

- A1. What trends are revealed by comparisons of the class marks and examination marks in Mathematics, Physics and Mechanics obtained at Wits by the ex-TTP students and the non-TTP students?
- A2. What trends are revealed by a comparison of NSC results in Mathematics and Physical Science with the university results of the ex-TTP students and the non-TTP students in Mathematics, Physics and Mechanics?
- A3. What does a statistical analysis of the marks from the Engineering Mathematics, Physics and Mechanics tests and examinations show about the academic success of the ex-TTP students compared to the sample of non-TTP students and about both samples of students compared to the whole cohort during their first year of engineering studies?

#### **3.4.2 Focus B: Mathematical and Scientific Competencies and Habits of Mind associated with academic proficiency**

- B1. Is there evidence that, in their Engineering Mathematics, Physics and Mechanics courses at Wits, the ex-TTP students are being required to use Competencies and Habits of Mind encountered in the TTP Mathematics and Science courses?

### 3.4.3 Focus C: Study techniques as one of the many variables intended to ensure academic proficiency

- C1. What study techniques were advocated by the Mathematics and Science teachers in the TTP?
- C2. What study techniques are suggested in the Mathematics, Physics and Mechanics courses at Wits?
- C3. How do these study techniques compare with each other?
- C4. What study techniques have the ex-TTP students used at Wits?

## 3.5 Variables and Methods of Measurement

The variables and methods of measurement are summarised in Table 4 and expanded thereafter.

**Table 4 Variables and Methods of Measurement**

| Focus Area | Questions | Variables  | Methods of Measurement  |
|------------|-----------|--|---|
| A          | A1        | Grade 10 and NSC marks of ex-TTP students; class mark and exam results from Wits for the ex-TTP students and the non-TTP students. | Longitudinal trend analysis of Grade 10 and NSC marks; longitudinal trend analysis of ex-TTP and non-TTP students of Wits class marks and Wits exam marks; comparisons between ex-TTP and non-TTP trends.               |
|            | A2        | NSC Maths and Science results and Wits Mathematics, Physics and Mechanics results for ex-TTP and non-TTP students.                 | Longitudinal trend analysis and comparisons between trends of ex-TTP and non-TTP students.  |
|            | A3        | Mathematics, Physics and Mechanics final marks for ex-TTP students, non-TTP students and the cohort.                               | A comparison of means and standard deviations of the subject marks using the z-test; correlations between subjects.   |
| B          | B1        | Competencies and Habits of Mind foregrounded by the TTP  | Documentary analysis of TTP curriculum reports and Wits course descriptions and text books. Interviews with TTP teachers and Wits lecturers. Sample tut question on a questionnaire and interview with ex-TTP students. |

| Focus Area | Questions | Variables  | Methods of Measurement   |
|------------|-----------|--|--|
| C          | C1        | Study techniques advocated by TTP teachers.                                | Interviews with TTP Mathematics and Science teachers.  |
|            | C2        | Study techniques advocated by Wits lecturers and found in course material. | Interviews with Wits Mathematics and Physics lecturers and analysis of Wits textbooks.   |
|            | C3        | Data from C1 and C2.   | Comparison of TTP and Wits techniques – commonalities and differences.   |
|            | C4        | Study techniques used by ex-TTP students                                   | Questionnaire with questions about use of specific techniques, with space allowing for clarification and amplification of answers. |

### 3.5.1 Focus A: Academic Proficiency

The quantitative data that was utilised for the ex-TTP students in Engineering at Wits prior to their entrance to university was taken from their performance in Grade 10 Mathematics and Physical Science (obtained by the TTP from schools) and their NSC results in Mathematics and Physical Science.

The data that was utilised to characterise the academic proficiency of the ex-TTP students at Wits was taken from their performance in the Mathematics, Physics and Mechanics courses that are part of the curricula of the Engineering degrees for which they were registered in 2010. All students take Mathematics for the whole year. The students in the Chemical Engineering branch and the Metallurgy and Materials branch do Mechanics for the first semester only and do not do Physics at all. The other branches (Biomedical, Civil, Electrical, Mechanical, Aeronautical, Industrial and Mining) do a full course in Physics and a full course in Mechanics.

The data was used to show changes from beginning to end during the school phase for the ex-TTP students, and through the first-year phase for the samples of ex-TTP and non-TTP students and for the cohort.

The marks that the ex-TTP students achieved in the Wits Mathematics, Physics and Mechanics courses and the same data for the non-TTP students is compared, using

descriptive statistics and z-tests to provide evidence of how the ex-TTP students performed relative to the non-TTP students. Both samples are also compared to the cohort as a whole. The performance of the students in the various branches of Engineering are compared, ex-TTP with non-TTP, and ex-TTP with the cohort.

Records of marks of assessments done by the ex-TTP students from Grade 10 are accessible from the TTP archives. NSC marks, and marks for the Mathematics, Physics and Mechanics courses taken by both the ex-TTP and the non-TTP students in 2010, were obtained from university sources.

### **3.5.2 Focus B: Mathematical and Scientific Competencies and Habits of Mind associated with academic proficiency**

The PISA document was used by the TTP as the source of the descriptions of Scientific and Mathematical Literacy and more specifically of the Scientific and Mathematical Competencies. The ideas in the document were used to create a theoretical framework for the curriculum design of all the TTP courses. I used the PISA document to identify Competencies present in both the TTP and the Wits source material.

A list of pertinent Habits of Mind was abstracted from Lim (2010). The list is shown in Table 3 on page 19.

The Curriculum Reports from the TTP, the Wits text books and interviews with the TTP teachers and the Wits lecturers were used to identify the Competencies and Habits of Mind that are present in the TTP Mathematics, Science and Molecular Literacy components, and in the Engineering Mathematics, Physics and Mechanics courses.

Nine ex-TTP students were interviewed and were asked if they were aware of using the Competencies and Habits of Mind foregrounded by the TTP during their study time.

Two TTP teachers who taught the Mathematics course and one who taught the Molecular Literacy course to the cohort of ex-TTP students were interviewed in order for them to identify Competencies and Habits of Mind that they encouraged the students to develop and use.

Two Wits lecturers of the Mathematics course and one lecturer of the Mechanics course were interviewed in order to identify Competencies and Habits of Mind that they are advocating for use by the students, albeit subconsciously.

The list of Habits of Mind, which was abbreviated from Lim (2010) (see Table 3 on p.19), was shown to the TTP teachers and the Wits Lecturers and they were asked to comment on which of the items in the list they felt they were using or that they could recognise as attributes that they were striving to pass on to their students. They were also asked if they were conscious of trying to pass on the Habits of Mind, even if they did not call them by that name.

Course Outlines, course materials and textbooks were used to identify Competencies and Habits of Mind present in the Wits courses.

### **3.5.3 Focus C: Study techniques as one of many variables intended to ensure academic proficiency**

Teaching material from the TTP courses and the Wits Mathematics, Physics and Mechanics courses was used to identify study techniques stated or implied.

The TTP teachers and Wits lecturers who were interviewed were asked about study techniques that they covertly or overtly tell students about.

Nine ex-TTP students completed a written questionnaire during interviews. Particular study techniques were identified for inclusion in the questionnaires. The written responses of the students and their verbal responses given during the interviews were analysed in order to characterise the study techniques used by these students. The techniques were then linked to the Habits of Mind and Competencies identified in Focus B.

## **3.6 Validity and Reliability**

The use of existing data (i.e. secondary data) enabled the research questions to be answered satisfactorily. McMillan and Schumacher (2010) there is a list of factors that should be considered when using secondary data (p.243). They are listed below with comments on how they related to the data I used:

1. *Does the dataset contain variables that will allow the research question to be answered?* The data sets that I used were chosen because they contained the

data that I needed to answer the research questions.

2. *Were the data collected from the population of interest?* This is certainly the case for the data sets that I used. The samples that I used consisted of individuals from the population of first year engineering students in 2010.
3. *When were the data collected?* The data were current for 2010. The NSC results were from the end of 2009 and the Wits results were from 2010.
4. *Is there adequate computing capacity to work with the secondary dataset?* The data set was of a size that was easily within the capabilities of my computer and I have the technical skills need for using a statistics software package.
5. *Are the data easily accessible?* Once ethics clearance had been obtained, the data were easily accessible.
6. *Is documentation about the dataset available?* The way that the data was collected is not documented, but it was done in accordance with the rules and regulations pertaining to Assessment at Wits.
7. *What is the structure of the data file?* The data file is easily manipulated to extract the necessary data.
8. *Is technical assistance available relative to the dataset and its use?* There were no problems obtaining assistance where necessary.

The research had the following design elements which helped to ensure statistical conclusion reliability was maintained: the data source was reliable; the two samples of students were homogeneous in terms of initial academic proficiency; data was accurate; and the samples were large enough.

### **3.7 Following Chapters**

The following three chapters describe and analyse the data collected in each of the three Focus Areas.

## **Chapter 4: Focus A: Academic Proficiency**

### **4.1 Introduction**

In this chapter the academic proficiency of the ex-TTP students will be reported in five ways: (1) In terms of the trends shown by the marks which the ex-TTP students achieved in Grade 10 and the NSC. (2) In terms of the trends shown by the marks the ex-TTP students achieved during the year at Wits. The trends in (1) will be compared with the corresponding trends shown by the sample of non-TTP students. (3) By comparing the trends shown in the comparison of the NSC results with the final marks for each subject obtained at Wits by the ex-TTP students and the non-TTP students. (4) By comparing the mark distributions of the cohort, the ex-TTP students and the non-TTP students in the subjects taken by them at Wits. (5) By discussing the following statistics for each subject:

- Mean and standard deviation of ex-TTP sample compared to the cohort mean and standard deviation
- Mean and standard deviation of non-TTP sample compared to the cohort mean and standard deviation
- Mean and standard deviation of ex-TTP sample compared to the non-TTP sample mean and standard deviation
- z-tests for means
- Correlation of ex-TTP NSC mathematics with Wits mathematics
- Correlation of ex-TTP NSC science with Wits Mechanics I, Mechanics II and Physics
- Pass rates for each branch of Engineering.

## 4.2 Classification of Samples

For each of the trend comparisons, the last-obtained mark of the subject was considered. For each subject, the samples were classified into three sub-groups using two criteria: firstly, the sub-groups should be almost equal in number; and secondly, the values of the marks should enable separation of the sample into three classes: low achievers, middle achievers and top achievers.

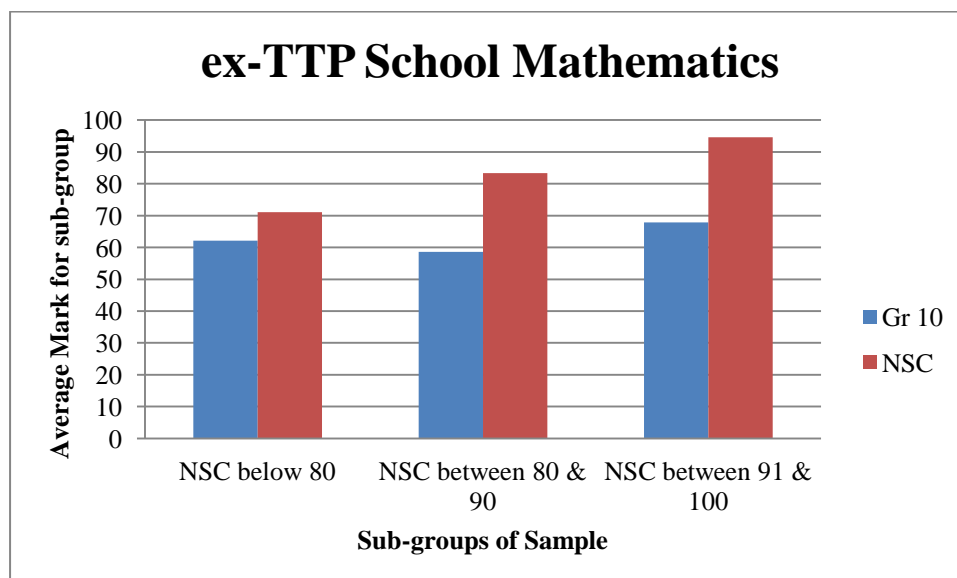
## 4.3 Academic Proficiency

### 4.3.1 Trends in School Data for the ex-TTP Students

This set of data is included to show how the ex-TTP students performed before they came to Wits. Results for Grade 10 and the NSC were available.

The following histogram (Figure 4.1) shows the trends for the ex-TTP students' **Mathematics** marks obtained in the final Grade 10 school examinations and those obtained in the NSC examination.

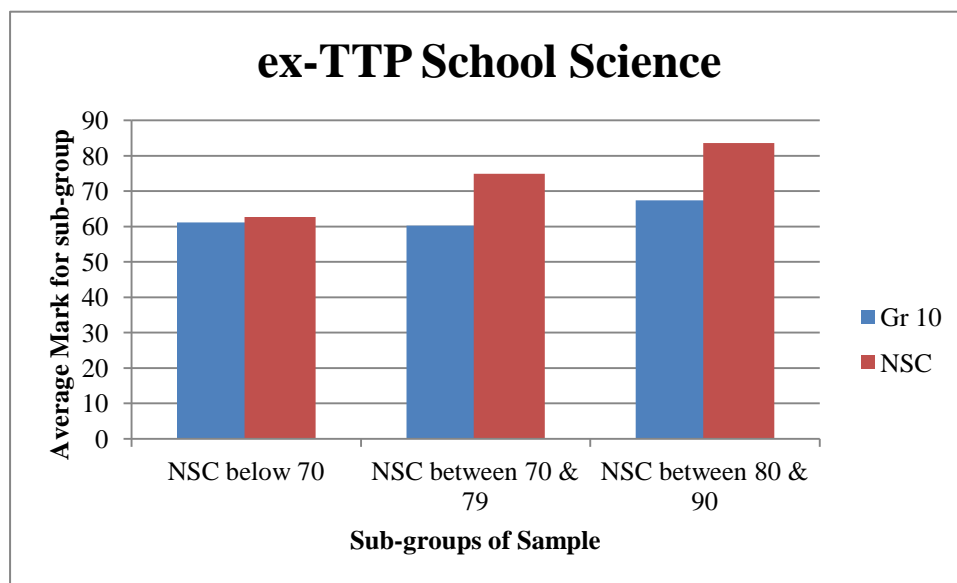
**Figure 4.1**



This histogram shows that the NSC marks were substantially higher than the Grade 10 marks. It is interesting to note that the low achievers in NSC had, on average, a higher Grade 10 mark than did the middle achievers. Only three of the top ten students in the NSC started out in the top ten in Grade 10. It should be noted that the NSC Mathematics marks for the whole cohort were extremely high and this is reflected in this histogram for the ex-TTP students.

The **Physical Science** histogram below shows trends similar to those shown in the Mathematics histogram above, in that the NSC results are much higher than the Grade 10 results. There is a slight difference in that while the initial Grade 10 science marks are in a range similar to that encompassed by the mathematics marks, the final science marks are not as high as the final mathematics marks. The low achievers and middle achievers started with the same average science mark in Grade 10. Three of the top ten students in the NSC examination were in the top ten Grade 10 students, but they were not the three students who remained in the top ten in Mathematics.

**Figure 4.2**

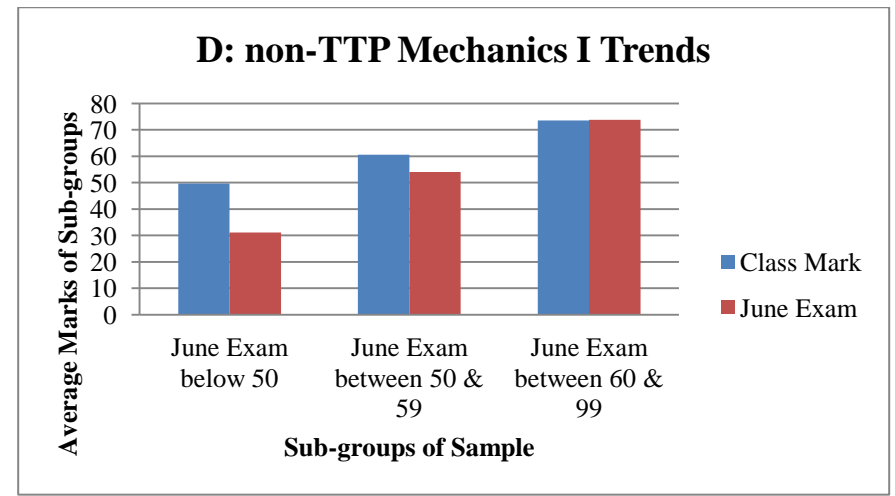
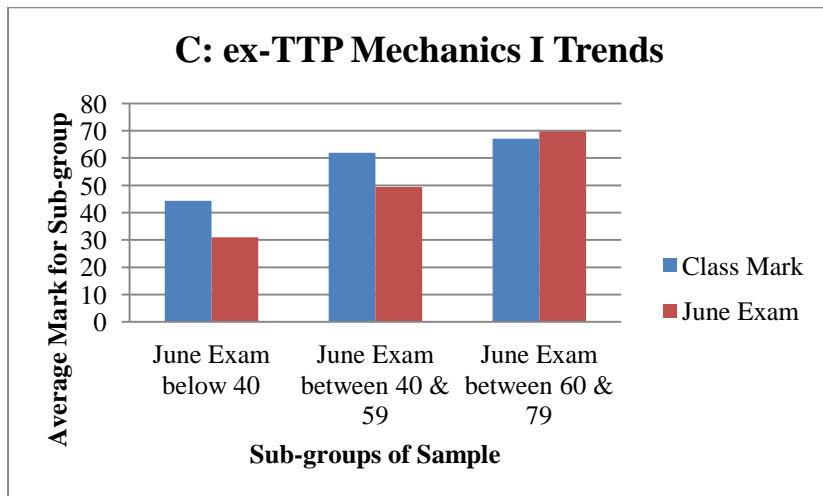
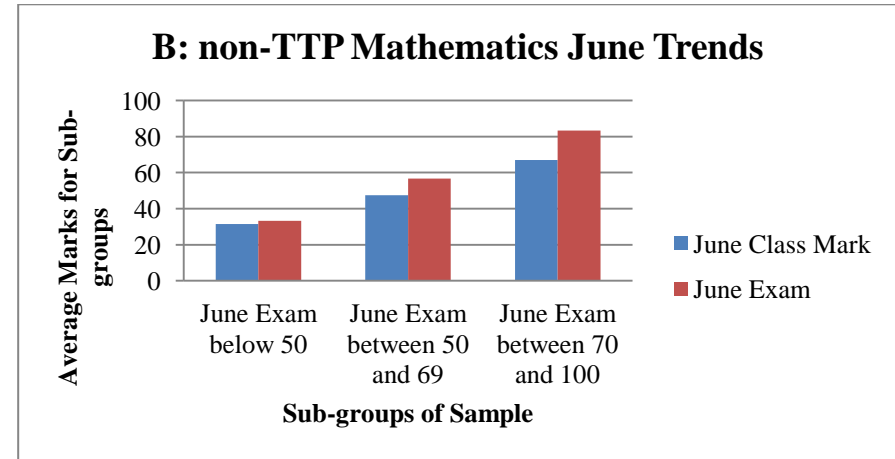
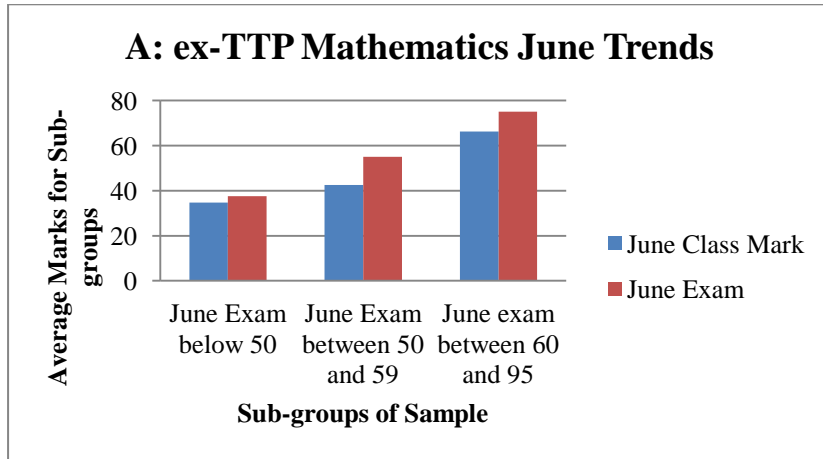


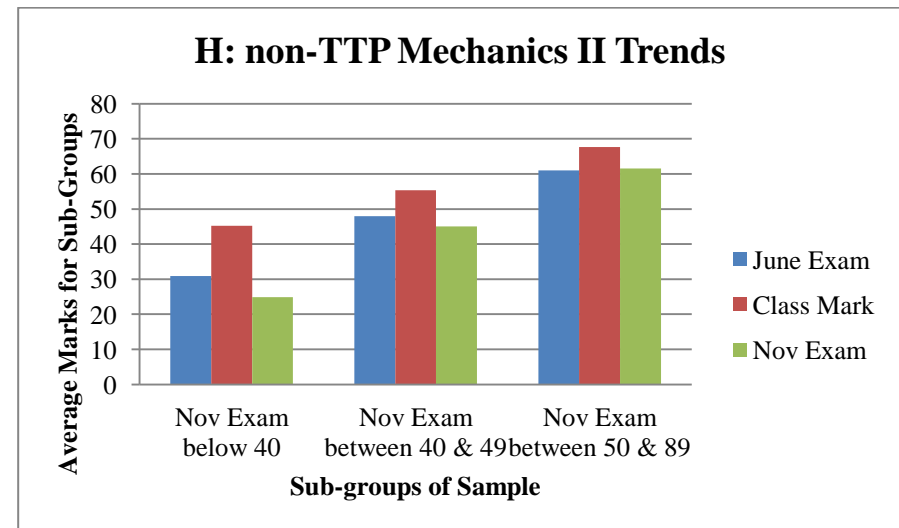
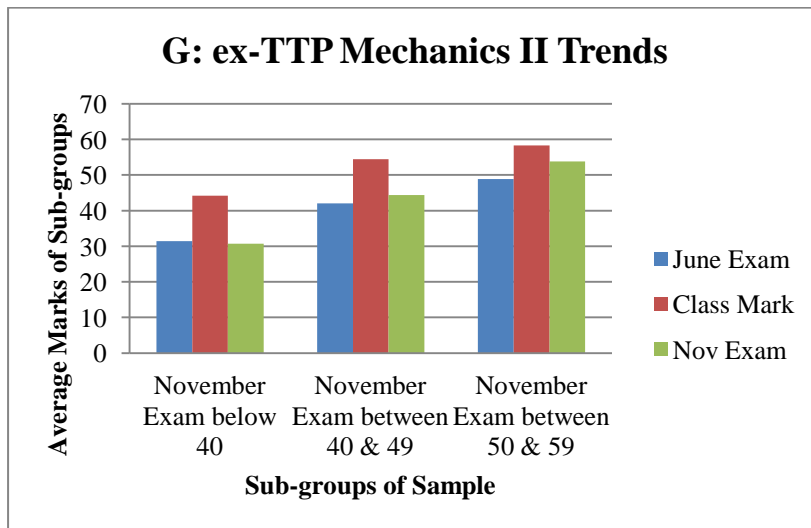
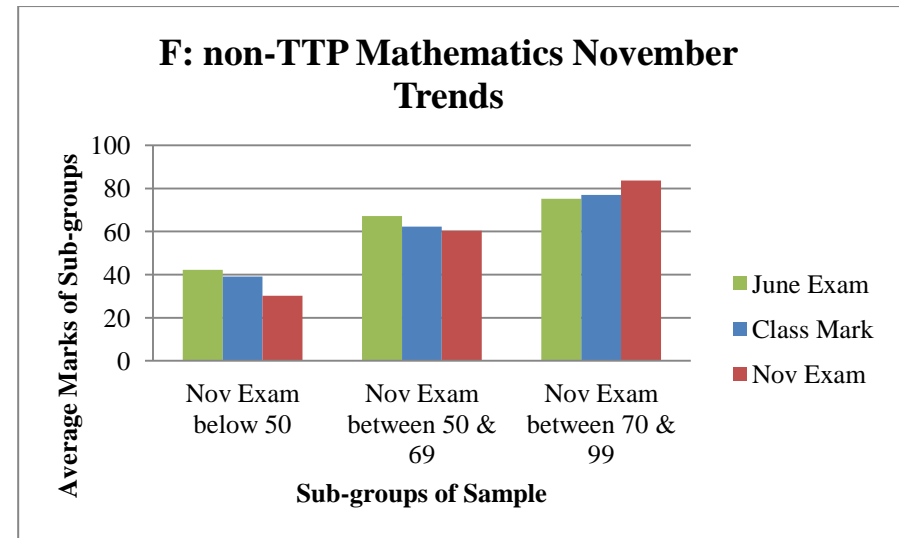
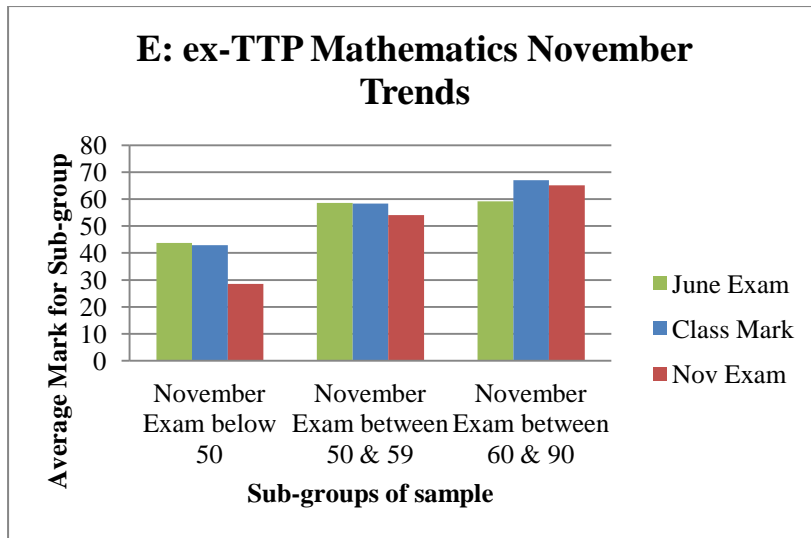
#### 4.3.2 Trends in Wits Data

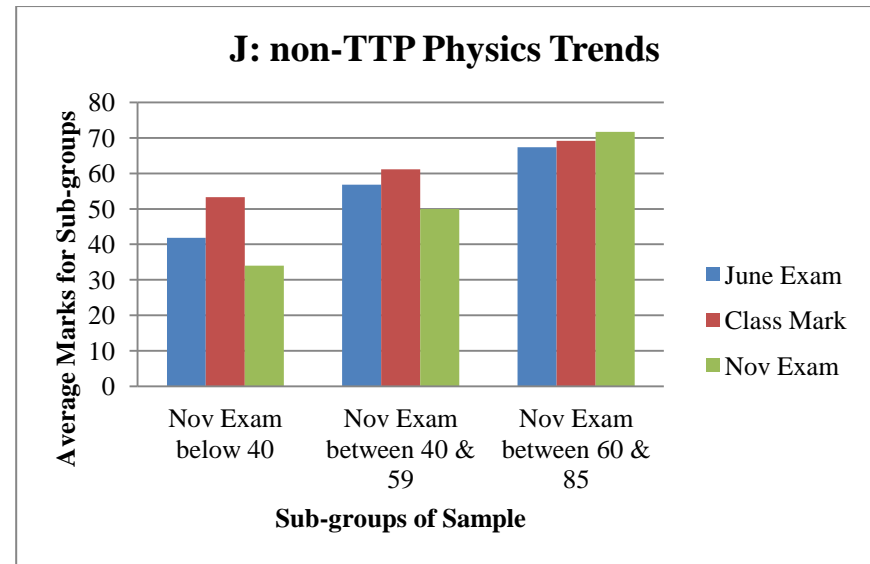
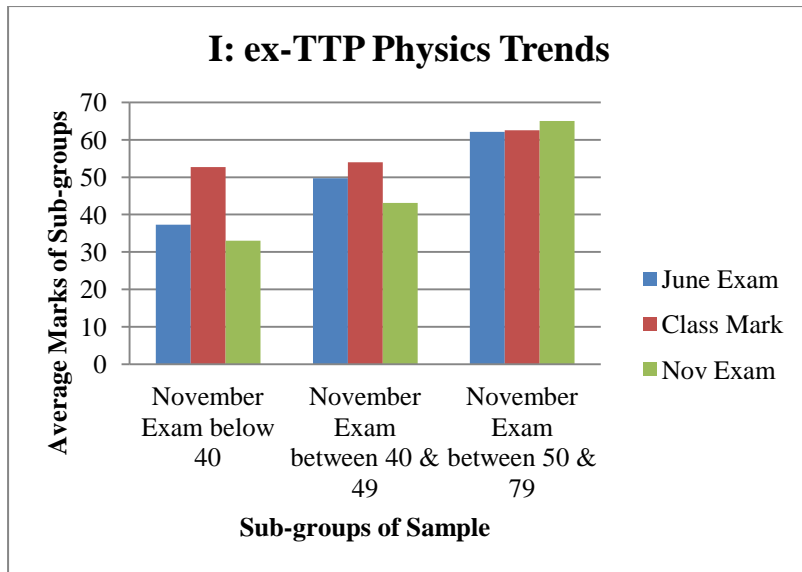
The histograms (Figure 4.3) on the following pages show the trends in the Wits subjects for the ex-TTP and the non-TTP students.

The sub-groups have been chosen as explained in section 4.2 of this report. This has resulted in the sub-groups having different lower and upper class limits.

**Figure 4.3 Trend Histograms: Wits Subjects**







The histograms on the previous pages (Figure 4.3) will be used to comment on the trends shown when considering the ex-TTP students' results and the non-TTP students' results for the courses they took at Wits.

### **Mathematics results in June**

Histograms A and B (Figure 4.3, pg 32) are based on the marks obtained for a class test in April and the examination in June. Each of the sub-groups of the samples improved their marks between the test and the examination. The ex-TTP students in the middle group had marks between 50 and 59 whereas the middle group of the non-TTP students had marks between 50 and 69. This shows a greater spread within the middle group for the non-TTP students. The non-TTP group had a higher top mark and a greater improvement in marks than the ex-TTP students in the top group.

### **Mechanics I results in June**

Histograms C and D (Figure 4.3, pg 32) are based on the marks obtained for tests and assignments during the semester and on the examination in June. The whole cohort of first year engineering students takes this half-course. In both the ex-TTP and the non-TTP samples, the lowest achiever group and the middle achiever group had lower marks for the examination than for their class mark, but both top achiever groups had slightly improved marks in the examination. The ex-TTP students had a spread of marks different from that of the non-TTP students. The lowest achiever group has marks which lie below 40 whereas the lowest achiever group of the non-TTP students has marks which lie below 50. The upper limit of both middle groups is 59, but the upper limit of the top achiever group of the ex-TTP students is 79 whereas it is 99 for the non-TTP students.

### **Mathematics in June and Mechanics I results**

The following remarks apply to Histograms A, B, C and D (Figure 4.3, pg 32). The lowest and middle achiever groups show opposite trends in Mathematics and Mechanics I, while the top achiever groups show more improvement in Mathematics than they do in Mechanics I. The lowest achiever group of ex-TTP students had an upper limit of 50 for Mathematics but 40 for Mechanics I. The upper limit of the top achiever group of ex-TTP students in Mathematics was 95 whereas for Mechanics I it was 79. This shows a tendency for students to achieve lower marks in Mechanics I

than in Mathematics. The same tendency is discernible for the non-TTP students, but it not as marked as that for the ex-TTP students.

### **Mathematics results in November**

Histograms E and F (Figure 4.3, pg 33) are based on the June examination, the class mark from all the tests in the year and the November examination. In both samples, the lowest achiever group and the middle achiever group obtained June examination marks and class marks that are similar, followed by a drop in marks for the November examination. The top achiever group of the ex-TTP students show a slight increase in marks between the June examination and the class mark and then a drop for the November examination mark. In contrast, the top achiever group of the non-TTP students shows slight increases from the June examination to the class mark and then to the November examination. Both samples have the lowest achiever marks lying below 50, but the upper limit for the middle achiever group of the ex-TTP students is 59 whereas it is 69 for the non-TTP students. The upper limit for the top achievers is 90 for the ex-TTP students and 99 for the non-TTP students.

### **Mechanics II in November**

Histograms G and H (Figure 4.3, pg 33) are based on the June examination, the class mark from all the tests in the year and the November examination. All three achiever groups in both samples have the class mark higher than either of the examination marks, but in the ex-TTP group the November examination marks are hardly different from those for the June examination, whereas the non-TTP group shows, for the lowest and middle achiever groups, a relatively large drop in marks between the June and November examinations and for the top achiever group, a small improvement between the June and November examinations. The most obvious difference is in the upper limit of the top achievers marks: it is 59 for the ex-TTP students and 89 for the non-TTP students. It is noteworthy that only the top achiever groups passed the November examination.

### **Mathematics in November and Mechanics II**

The Mathematics histograms (E and F, Figure 4.3, pg 33) show results of the whole sample (37 ex-TTP and 37 non-TTP) whereas in the Mechanics II histograms (G and H, Figure 4.3, pg 33) there are 20 ex-TTP students and 26 non-TTP students.

Nevertheless the two sets of results will be commented on in the light of the fact that

both Mathematics and Mechanics II are full courses. The results for the ex-TTP students show that the lowest achiever group in Mechanics II had November exam marks less than 40 whereas the lowest achiever group in Mathematics had November exam marks less than 50. The middle achiever group had an upper limit of 49 for Mechanics II and 59 for Mathematics. The top achiever group had an upper limit of 59 in Mechanics II and 90 in Mathematics. The overall achievement in Mechanics II was thus more conservative than for Mathematics. The non-TTP students show similar trends except that the upper limit of the top achiever group was 89 for Mechanics II, considerably more than the 59 for the ex-TTP group.

### **Physics**

Histograms I and J (Figure 4.3, pg 34) are based on the June examination, the class mark from all the tests in the year and the November examination. For both the ex-TTP and the non-TTP students, the lowest achiever group and the middle achiever group have a class mark that is greater than the examinations marks and they also have a November examination marks that is lower than the June examination mark. The top achiever group of the ex-TTP students has a June examination mark that is nearly the same as the class mark and a November examination mark that is slightly higher. The top achiever group of the non-TTP group has ascending marks for the June examination, the class mark and the November examination, but the increments are very small. Both groups of lowest achievers have November examination marks below 40, but the ex-TTP middle achiever group has marks between 40 and 49 whereas for the non-TTP students the marks are between 40 and 59. The marks of the top achiever group of the ex-TTP students are more spread out and lower, with marks between 50 and 79 compared to the non-TTP group with marks between 60 and 85. It is noteworthy that only the top achiever group of the ex-TTP students passed the November examination.

### **Mechanics II and Physics**

Histograms G and H (Figure 4.3, pg 33) are compared with Histograms I and J (Figure 4.3, pg 34) because the same students take both courses and because Mechanics is essentially a topic in Physics. For the ex-TTP students, the lowest achiever group shows similar trends for both subjects: the June and November examination marks are below 40 and are lower than the class marks, and the

November examination mark is lower than the June examination mark. In the November examinations, the middle achiever group of ex-TTP students has an upper limit of 49 in both subjects, which means that this sub-group has a failing mark for both subjects. The trends for the ex-TTP middle achiever groups for the two subjects are different in that the June examination mark is lower than the November examination mark in Mechanics but higher in Physics. The class mark is the highest for both subjects. The top achiever group of ex-TTP students has passing marks but, in Mechanics, the upper limit for this sub-group is 59 for Mechanics and 79 for Physics. The trends are the same, in that the November examination mark is higher than the June examination mark but for Mechanics, the class mark is the highest mark while for Physics, the class mark lies between the two examination marks. The non-TTP students show similar trends for the lowest achiever group and the middle achiever group for both subjects, namely that the June and November examination marks are lower than the class marks, the November examination mark is lower than the June examination mark and both the sub-groups have failing marks. For the non-TTP top achiever group, the Mechanics trend shows the June examination mark to be almost identical to the November examination mark, with the class mark being the highest mark. For the ex-TTP and the non-TTP groups, the Physics trend shows all three marks to be very similar, but with increasing magnitude from the June examination to the class mark to the November examination.

### **Summary**

In each of the subjects except Mechanics I, the lowest achiever group of ex-TTP students and non-TTP students have equal upper limit. In Mechanics I the upper limit is lower for the ex-TTP students. The trends shown in each of the subjects is the same for both the ex-TTP students and the non-TTP students in this sub-group.

The lower limit of the middle achiever groups of ex-TTP students in each of the subjects except Mechanics I is thus the same as that of the non-TTP students, but the upper limits of the class show Mechanics I and Mechanics II as having the same value, while in the other subjects the ex-TTP upper limit is less than the non-TTP upper limit.

The upper limits for the top achiever groups of ex-TTP students are all lower than those for the non-TTP students, with the difference ranging from 5% to 30%.

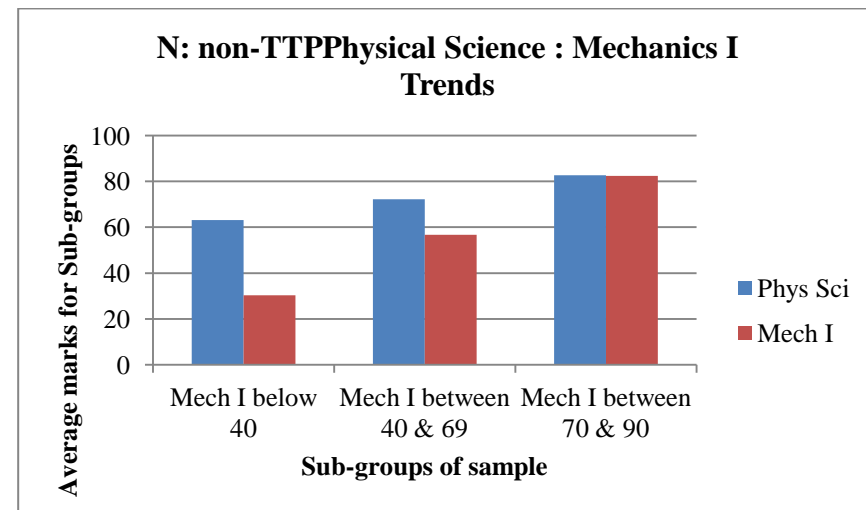
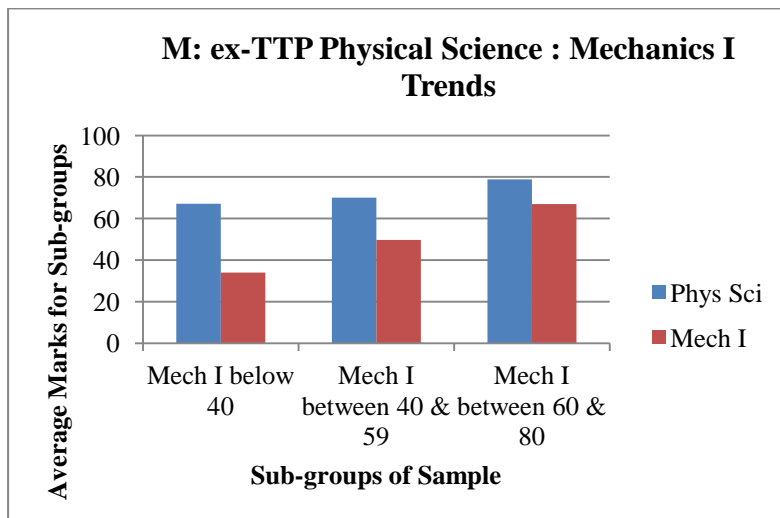
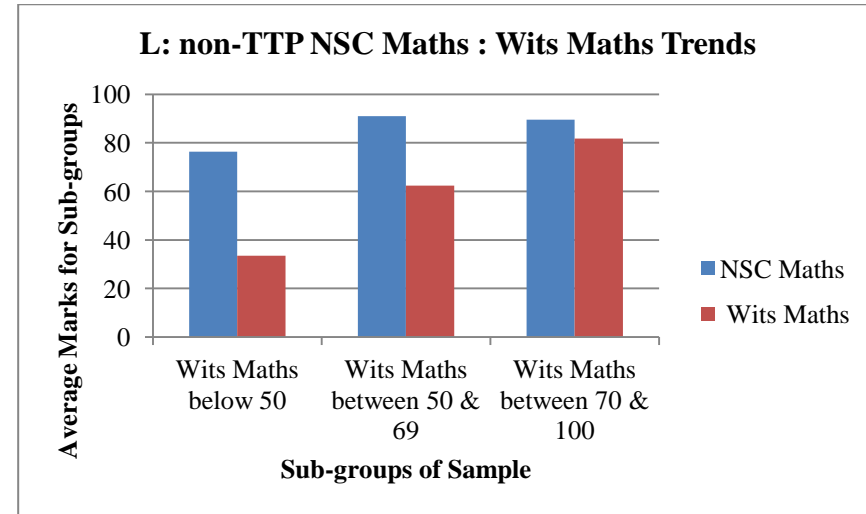
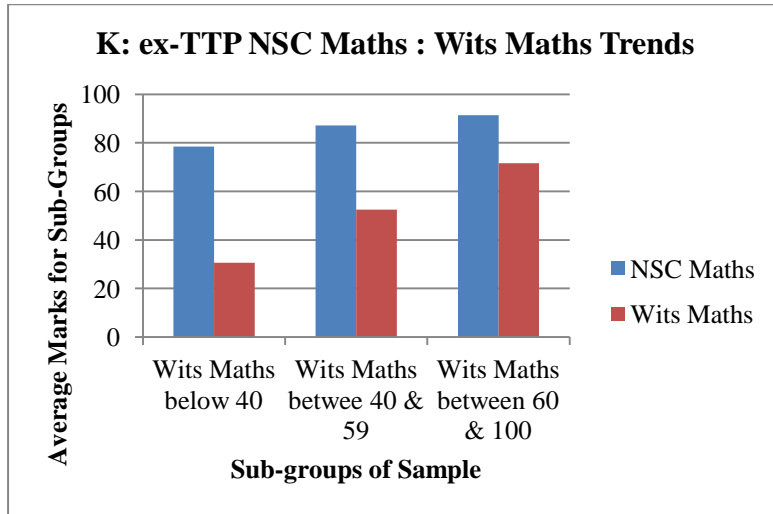
In general, across subjects, the ex-TTP students show the same trends for each sub-group as do the non-TTP students. The lowest and middle achiever groups of both the ex-TTP and the non-TTP students generally show a decrease in marks from June to November whereas the top achiever groups show an improvement in marks.

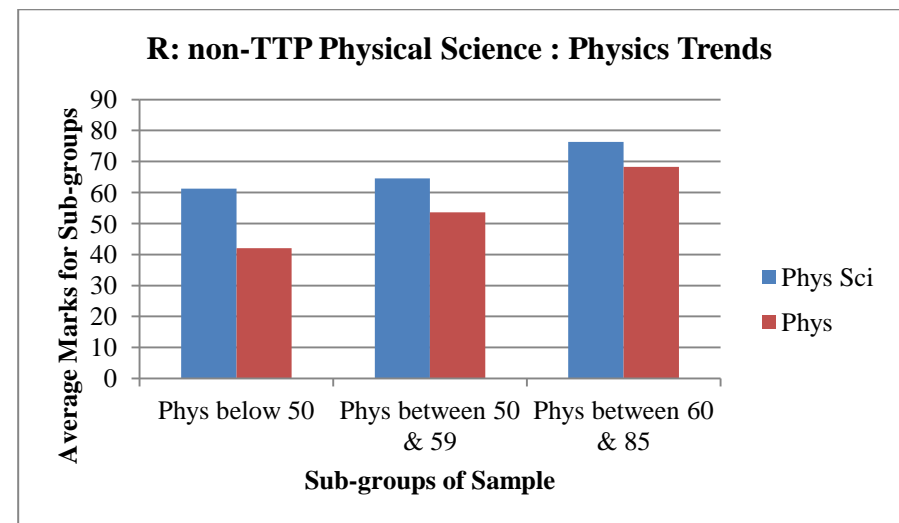
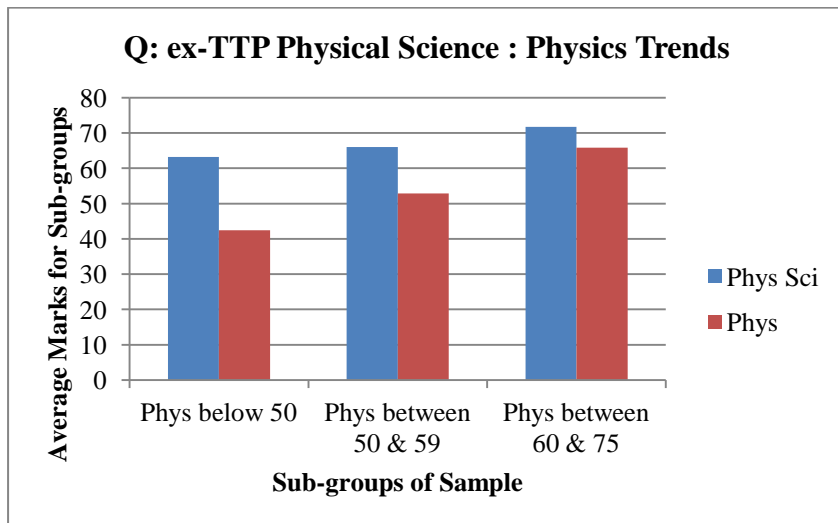
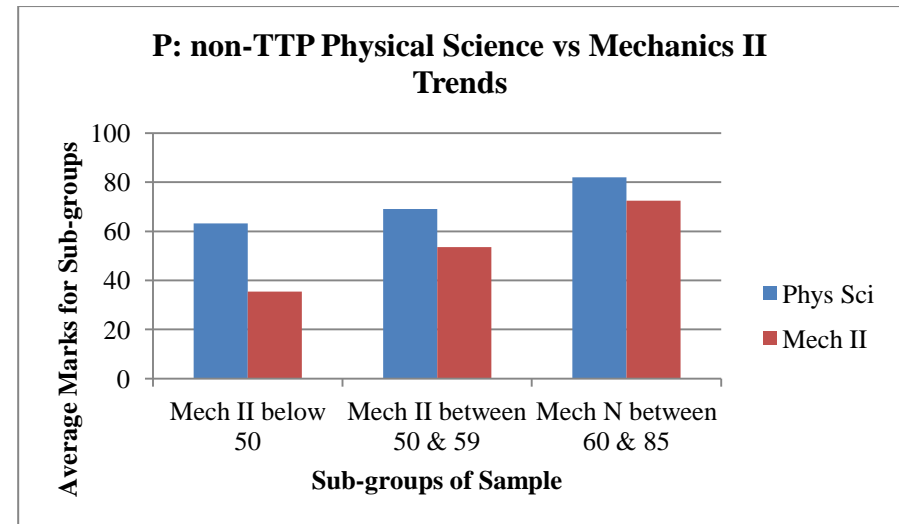
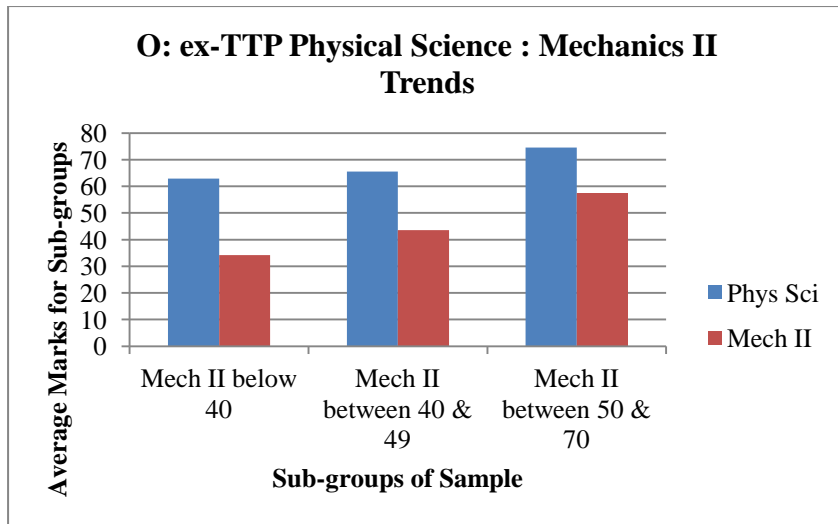
#### **4.3.3 Trends in NSC and Wits results**

The histograms on the following pages (Figure 4.4) show the trends when comparing the NSC results in Mathematics with the final Mathematics marks obtained at Wits by the samples and the trends when the NSC Physical Science marks are compared to the final marks of the half course in Mechanics, the full course in Mechanics and the Physics course.

It is obvious that the Wits marks are below the NSC marks for all the sub-groups in all the subjects except that in the case of the top achiever group of the non-TTP students in Mechanics I, their Mechanics and NSC marks are almost identical. The differences are most marked in the Mathematics comparisons and in the Physical Science vs. Mechanics comparisons. These histograms indicate that success in the NSC is not a guarantee of success at Wits for these Engineering students.

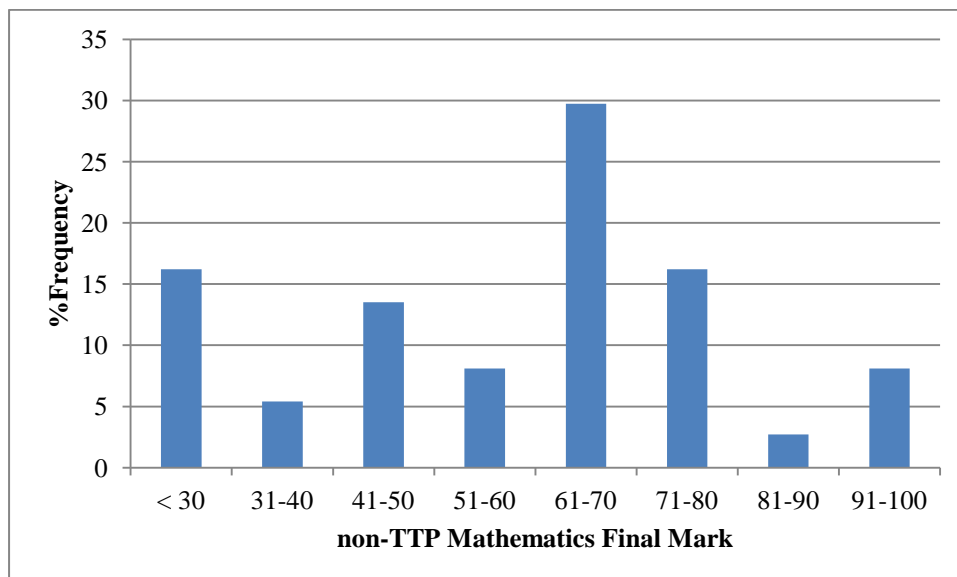
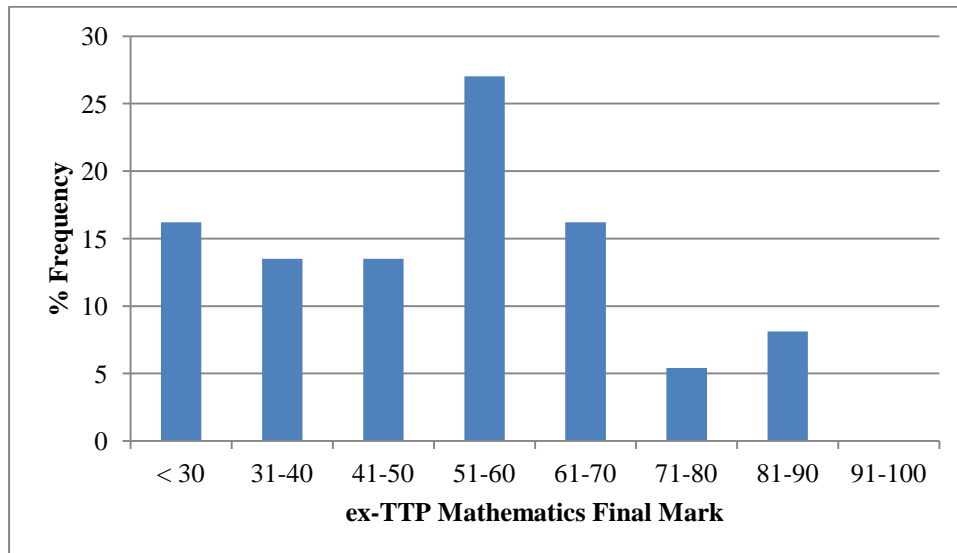
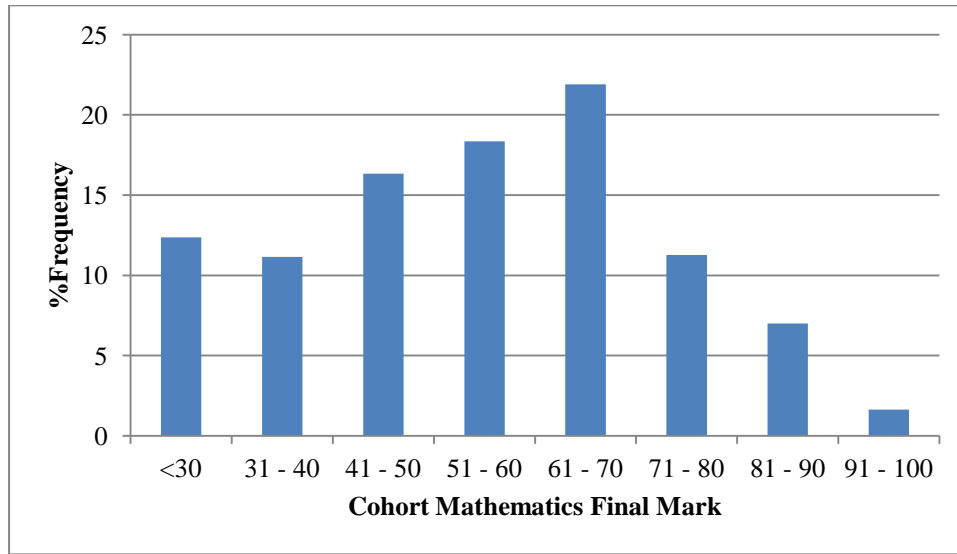
**Figure 4.4 Trend Histograms: NSC Subjects vs Wits Subjects**





### 4.3.4 Mark Distributions: Wits Subjects

**Figure 4.5 Mark Distributions: Mathematics**



**Mathematics**

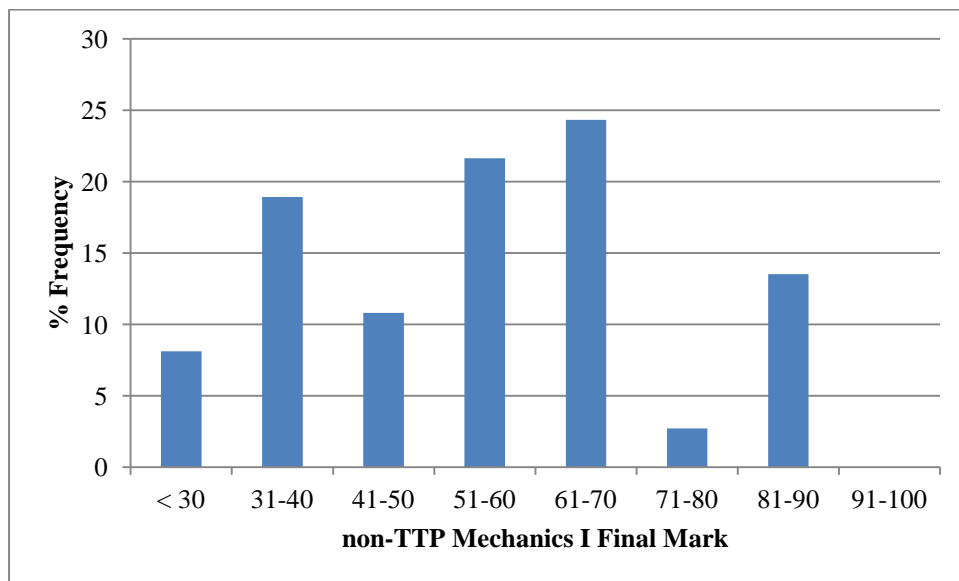
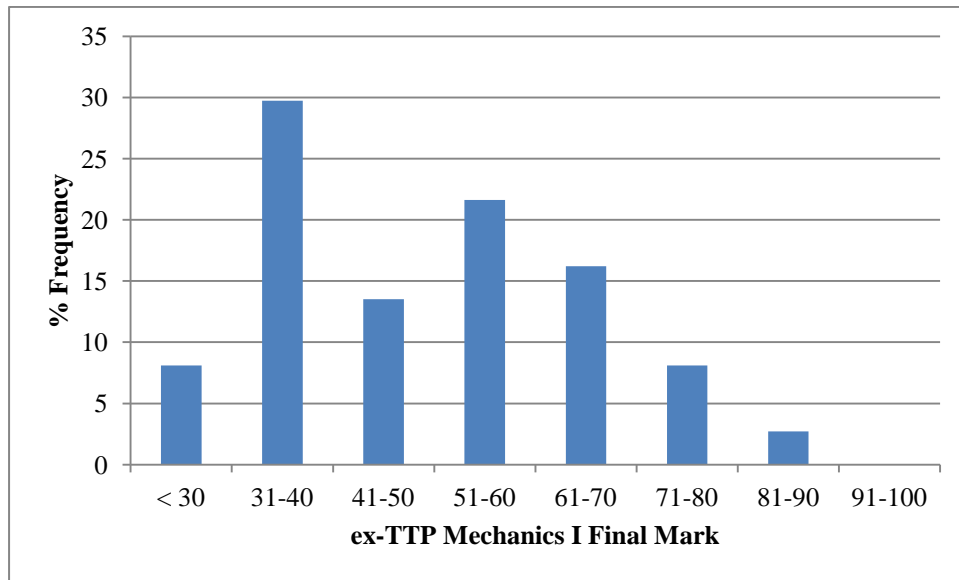
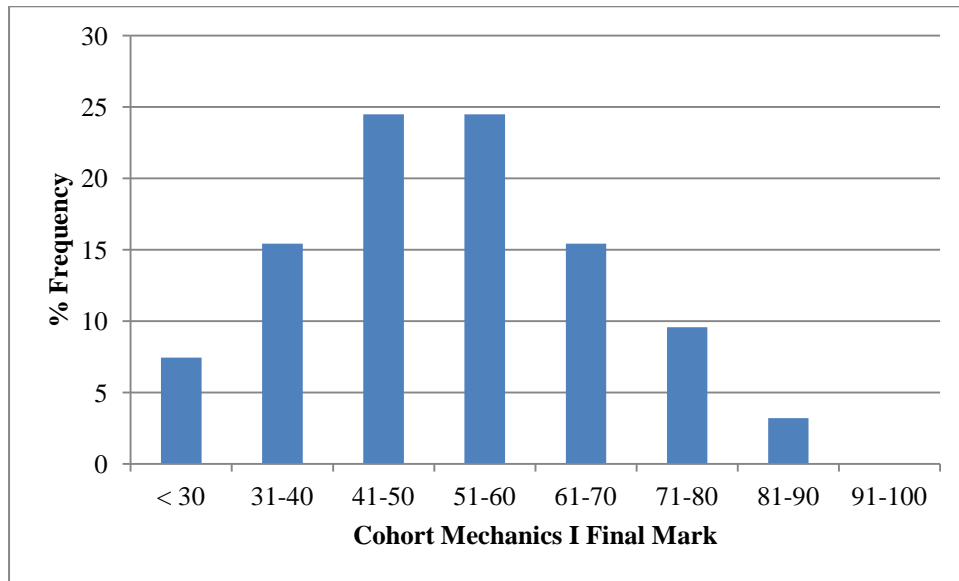
The final mark for Mathematics is an average of the class mark and the examination mark for each student. The histograms show the percentage frequency distributions for the cohort, the ex-TTP sample and the non-TTP sample.

None of the distributions are normal in shape.

The mode of the cohort lies in the 61-70 % decile, with about 22% of the cohort on the decile. The mode of the ex-TTP sample lies in the 51-60% decile, with about 26% of the sample in the decile. The mode of the non-TTP sample lies in the 61-70% decile with nearly 30% of the sample in the decile.

About 13% of the ex-TTP students are in the 41-50% decile. These students would qualify for a supplementary examination provided they had passed all their other subjects.

**Figure 4.6 Mark Distributions: Mechanics I**



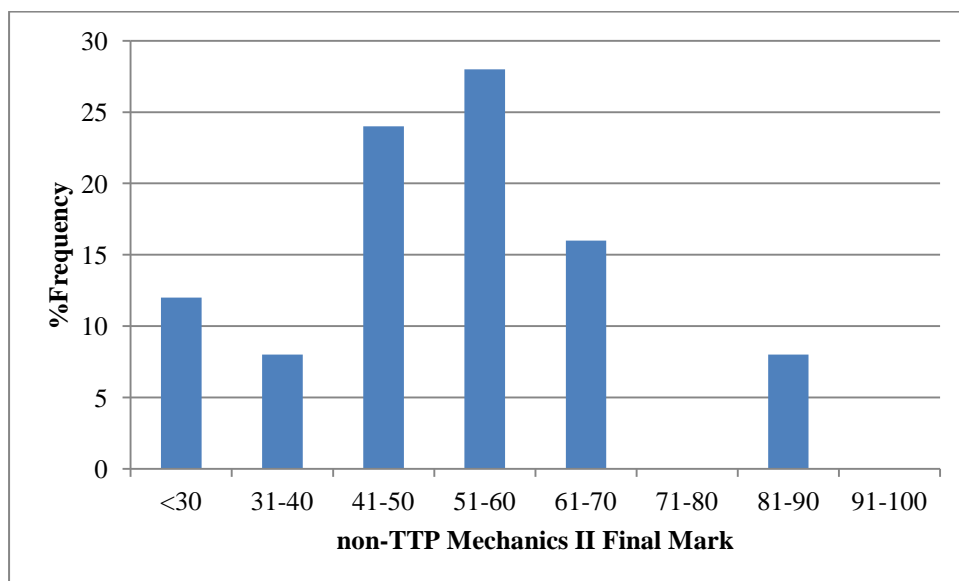
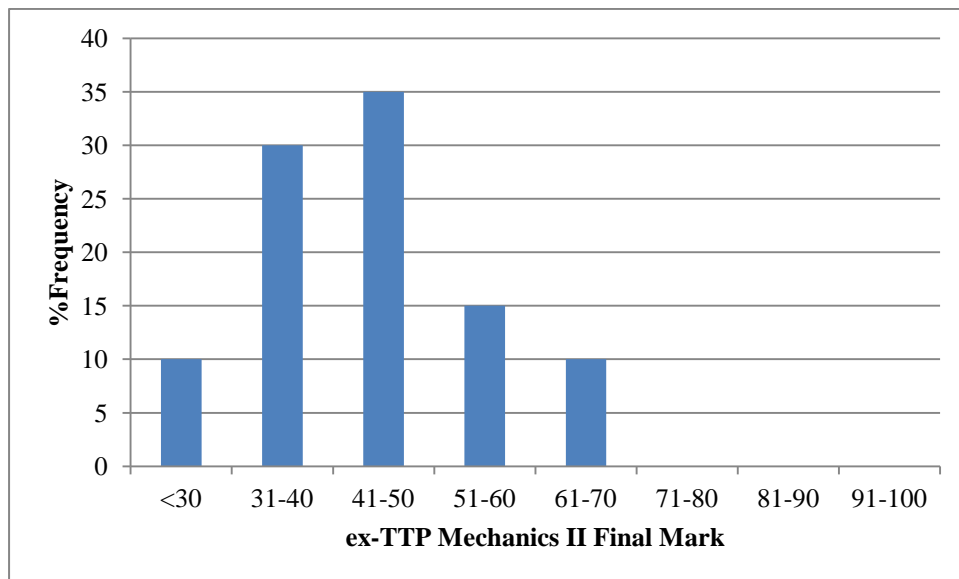
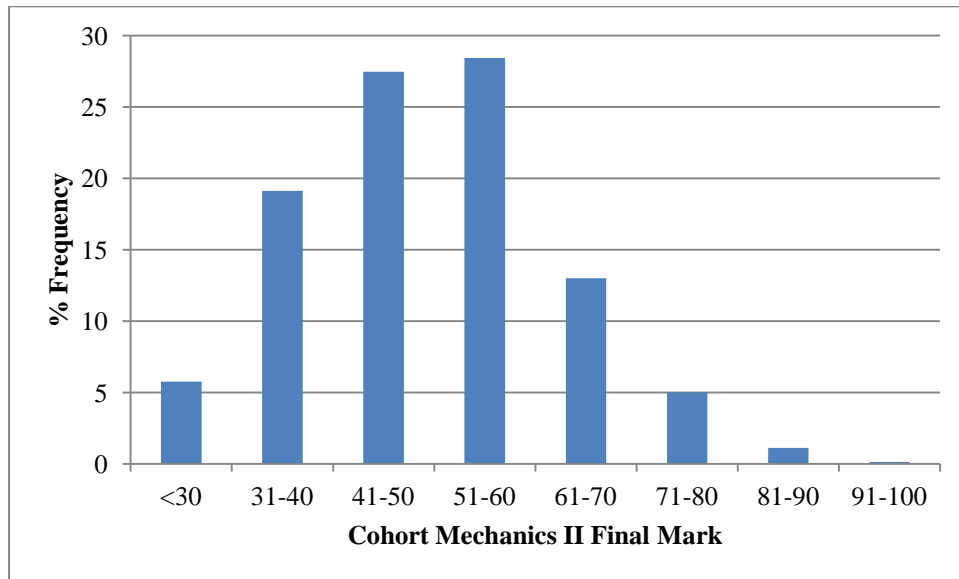
**Mechanics I**

This course occurred in the first semester, so several factors such as the culture shock of adjusting to university life probably affected the performance of students from non-urban and under-resourced environments to a greater degree than it affected students from urban, well resourced environments.

The cohort histogram is bi-modal, with the modes being in the 41-50% and 51-60% deciles, with about 24% of the students in each decile. The ex-TTP histogram has its mode in the 31-40% decile, with very nearly 30% of the students in the decile. There is a second local maximum in the 51-60% decile, which is the lowest decile where one would hope the mode would be. The histogram for the non-TTP students is very strange. There is a mode in the 61-70% decile, but there are three other deciles where the % frequency is not much less than the mode.

The cohort histogram is the closest to a normal distribution skewed right. The other two distributions are definitely not normal distributions.

**Figure 4.7 Mark Distributions: Mechanics II**



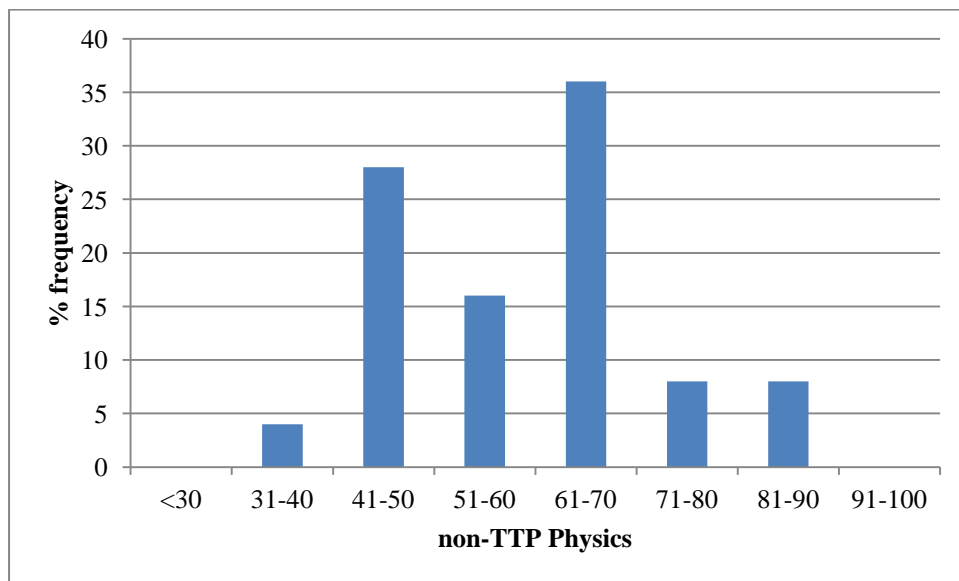
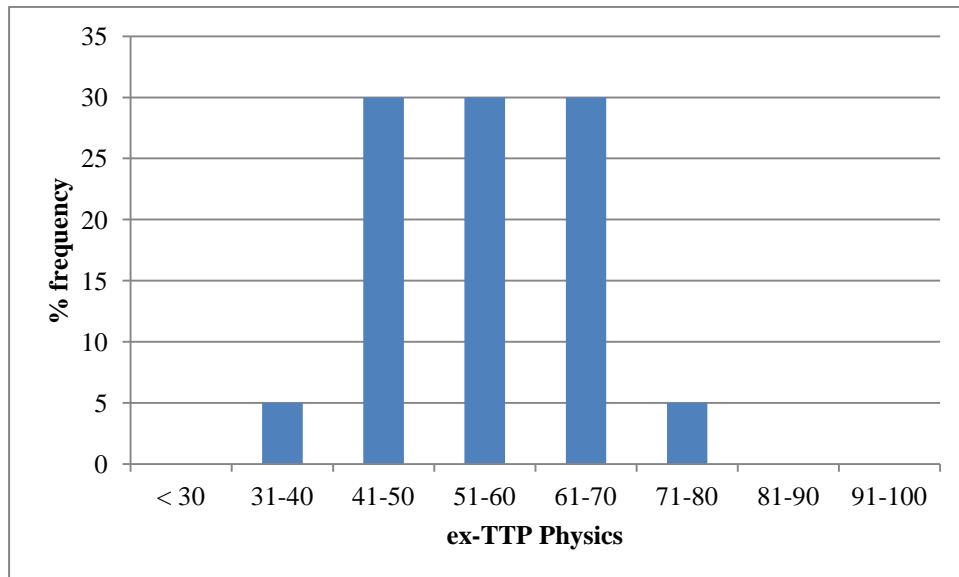
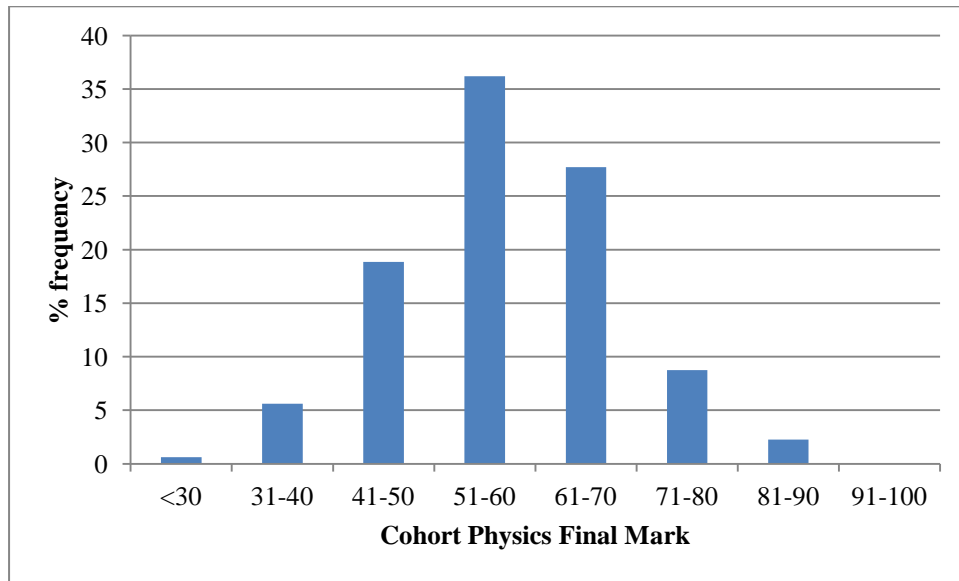
## **Mechanics II**

This course is the continuation of Mechanics I, but only 20 of the ex-TTP sample and 26 of the non-TT sample took the course.

The cohort has a mode and, as for Mechanics I, the mode occurs in the 51-60% deciles, but the Mechanics II mode is only a very little greater than the frequency in the 41-50% decile. However there is a greater percentage of the students in these deciles for Mechanics II than there is for Mechanics I. The distribution is skewed further to the right than the Mechanics I distribution. The mode for the ex-TTP students is in the 41-50% decile, with the next highest % frequency in the 31-40% decile. This is an improvement on the Mechanics I distribution, but still reflects a mode in a decile below the pass mark of 50%. The mode of the non-TTP distribution is in the 51-60% decile, but the distribution, while not normally distributed, is skewed right, showing that the majority of students have failed.

The frequency distributions indicate that generally, the ex-TTP students are not performing as well as the cohort or as well as the non-TTP students.

**Figure 4.8 Mark Distributions: Physics**



**Physics**

The frequency distribution for the cohort has a mode in the 51-60% decile and appears to be skewed slightly left, while having a somewhat normal distribution. The distribution for the ex-TTP students has three deciles with the same maximum % frequency, namely 41-50%, 51-60% and 61-70%. Thus about 90% of the students are in these three deciles. There is a total of about 35% of the students with a failing mark. The distribution for the non-TTP students has a mode in the 61-70% decile, with about 36% of the students in this decile. About 31% of the non-TTP students failed and only about 14% of the students had marks above the mode.

The ex-TTP students have a mark distribution which is different to both the cohort and the non-TTP students, but they have a pass rate very similar to that of the cohort.

### 4.3.5 Statistics

**Table 5 Means, Standard Deviations and z-tests**

| <b>NSC maths</b>       | Mean   | sd     |  | <b>NSC Phys Sc</b>    | Mean   | sd     |
|------------------------|--------|--------|--|-----------------------|--------|--------|
| all                    | 82.6   | 8.9    |  | all                   | 75     | 7.6    |
| ex-TTP                 | 85.8   | 10.6   |  | ex-TTP                | 71.3   | 8.6    |
| non-TTP                | 85.5   | 9.6    |  | non-TTP               | 71.4   | 8.6    |
|                        |        |        |  |                       |        |        |
| <b>Wits Maths June</b> | Mean   | sd     |  | <b>Wits Maths Nov</b> | Mean   | sd     |
| all                    | 51.2   | 18.4   |  | all                   | 54.6   | 18.6   |
| ex-TTP                 | 51.3   | 17.9   |  | ex-TTP                | 51.6   | 17.4   |
| non-TTP                | 55.1   | 20.5   |  | non-TTP               | 58.6   | 20.8   |
|                        |        |        |  |                       |        |        |
| <b>z-tests</b>         | z      | p      |  | <b>z-tests</b>        | z      | p      |
| ex-TTP:all             | 0.039  | 0.4841 |  | ex-TTP:all            | -0.981 | 0.1635 |
| non-TTP: all           | 1.305  | 0.0968 |  | non-TTP: all          | 1.308  | 0.0968 |
| ex:non                 | -0.896 | 0.1841 |  | ex:non                | -1.619 | 0.0526 |
|                        |        |        |  |                       |        |        |
| <b>Mech I</b>          | Mean   | sd     |  | <b>Mech II</b>        | Mean   | sd     |
| all                    | 51.9   | 15.5   |  | all                   | 49.9   | 12.9   |
| ex-TTP                 | 47.5   | 16.1   |  | ex-TTP                | 44.5   | 10.2   |
| non-TTP                | 54.5   | 17.7   |  | non-TTP               | 52.5   | 16.1   |
|                        |        |        |  |                       |        |        |
| <b>z-tests</b>         | z      | p      |  | <b>z-tests</b>        | z      | p      |
| ex-TTP:all             | -1.727 | 0.0418 |  | ex-TTP:all            | -1.872 | 0.0307 |
| non-TTP: all           | 1.020  | 0.1539 |  | non-TTP: all          | 1.028  | 0.1515 |
| ex:non                 | -1.942 | 0.0262 |  | ex:non                | -2.085 | 0.0188 |
|                        |        |        |  |                       |        |        |
| <b>Physics</b>         | Mean   | sd     |  |                       |        |        |
| all                    | 57.5   | 10.9   |  |                       |        |        |
| ex-TTP                 | 54.8   | 9.9    |  |                       |        |        |
| non-TTP                | 59.4   | 12     |  |                       |        |        |
|                        |        |        |  |                       |        |        |
| <b>z-tests</b>         | z      | p      |  |                       |        |        |
| ex-TTP:all             | -1.108 | 0.1335 |  |                       |        |        |
| non-TTP: all           | 0.889  | 0.1867 |  |                       |        |        |
| ex:non                 | -1.419 | 0.0778 |  |                       |        |        |

### **NSC Mathematics and Physical Science**

The mean marks for the ex-TTP and the non-TTP students are both higher than the mean for the cohort, but both standard deviations are bigger than the cohort standard deviation. For Physical Science, the means of the ex-TTP and the non-TTP students are both lower than the mean for the cohort, but both standard deviations are bigger than the cohort standard deviation. This shows that the two samples have a wider spread of marks than the cohort.

### **Mathematics in June and Mathematics in November**

The mean of the cohort rises by 3.4 from June to November but the standard deviation decreases by only 0.2. The mean of the ex-TTP students only increases by 0.3 and the standard deviation decreases by 0.3. The mean of the non-TTP increases by 3.5 and the standard deviation increases by 0.3. There is thus very little change in the mean marks or the standard deviations between June and November for Mathematics.

### **Mathematics in June and Mechanics I**

The whole cohort wrote both the Mathematics and Mechanics I examinations in June.

In the June Mathematics, the mean of the ex-TTP sample is very much the same as that of the cohort mean while the mean of the non-TTP sample is greater than that of the cohort mean, but there are no significant differences in the means at a 5% level of significance. For the Mechanics course, the ex-TTP mean is significantly different from the mean of the cohort and the mean of the non-TTP students, at a 5% level of significance. The mean of the non-TTP students is not significantly higher than the cohort mean at a 5% level of significance.

The standard deviations for the June Mathematics marks show that the ex-TTP students are clustered around their mean more than the cohort is and more than the non-TTP students are. The comparison of the standard deviations for the Mechanics I course is different in that the cohort is more clustered around its mean than the ex-TTP students are, but the non-TTP students are the most spread out, as they are in the June Mathematics.

### **Mechanics II and Physics in November**

The same sub-section of the cohort wrote the Mechanics II and the Physics examinations in November.

For the Mechanics II course, the mean of the ex-TTP sample is less than the cohort mean and the mean of the non-TTP sample is greater than the cohort mean. There is a significant difference between the mean of the ex-TTP students and the cohort mean, and between the mean of the ex-TTP students and the non-TTP students, but not between the mean of the non-TTP students and the cohort mean, at a 5% level of significance. For the Physics course, the mean of the ex-TTP sample is less than the cohort mean while the mean of the non-TTP sample is greater than the cohort mean, but there are no significant differences between the means at a 5% level of significance. There is also no significant difference between the two sample means at a 5% level of significance.

The standard deviations of Mechanics II and Physics show a similar pattern in that the marks of the ex-TTP students are more closely clustered around their mean than are the marks of the cohort, and the non-TTP students marks are more scattered than the cohort's marks are.

### **Correlations of NSC results and Wits results for the ex-TTP and non-TTP samples**

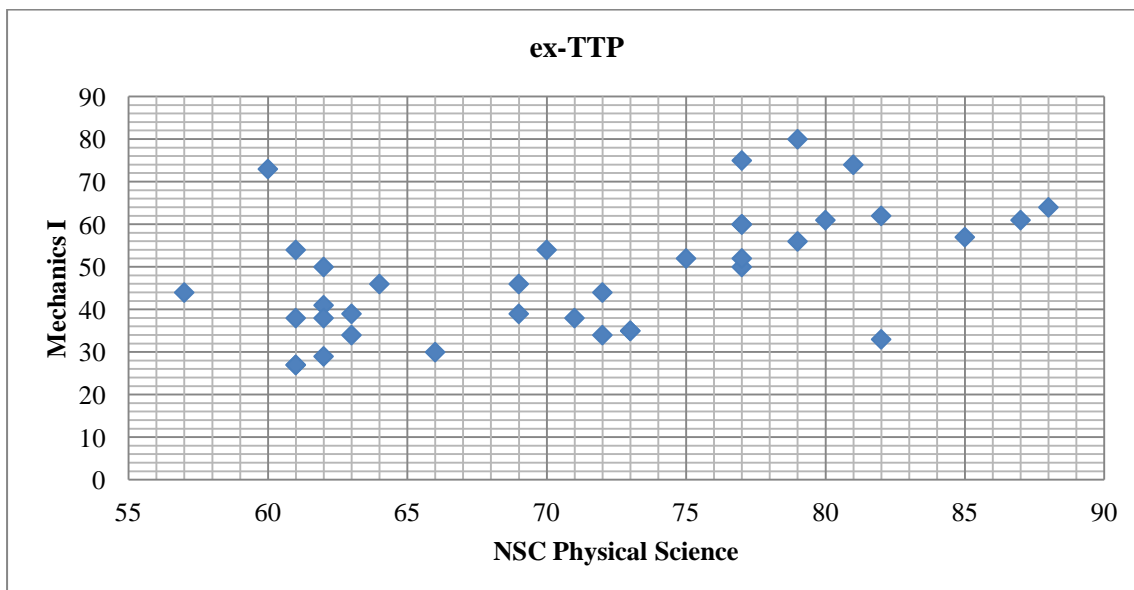
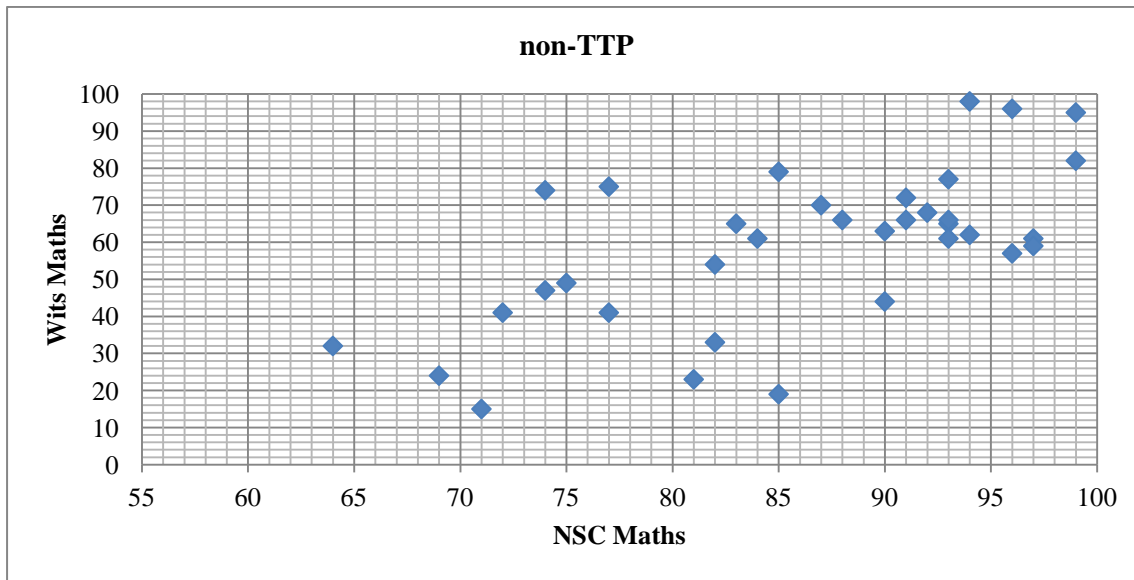
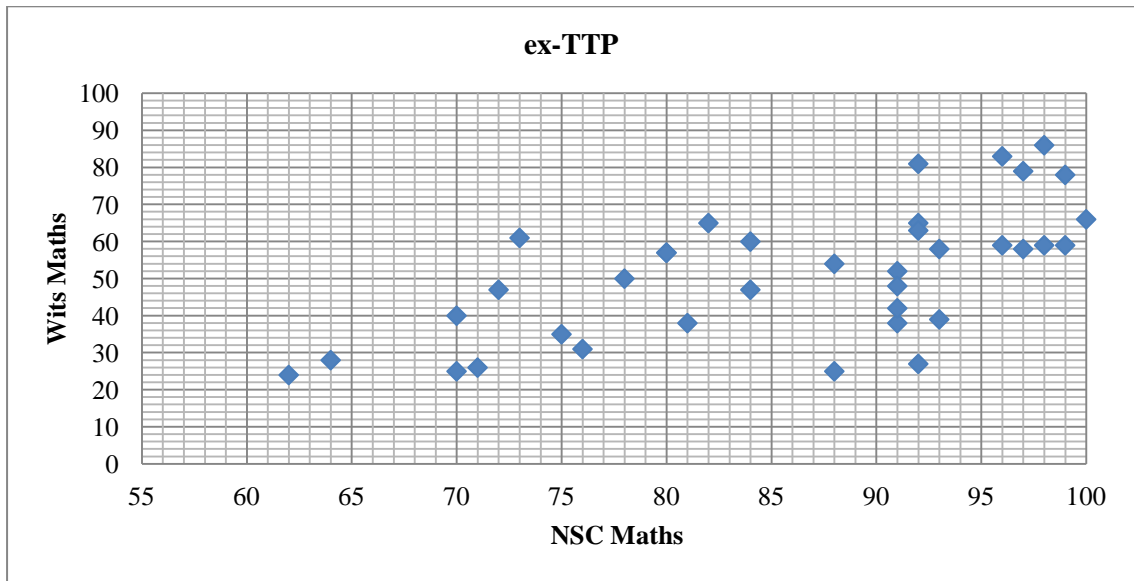
**Table 6      Linear Correlations between NSC and Wits Subjects**

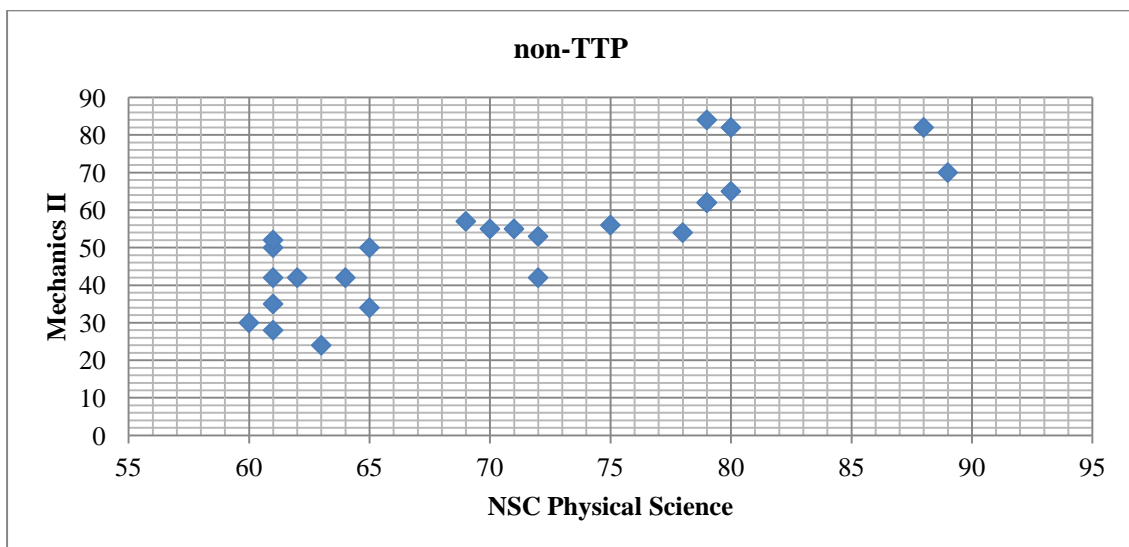
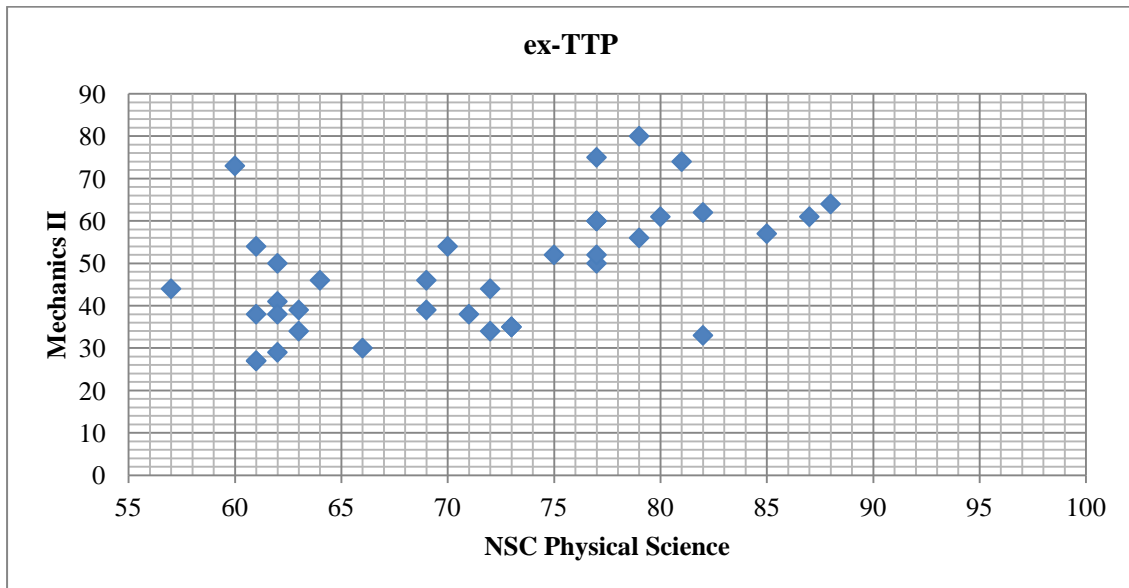
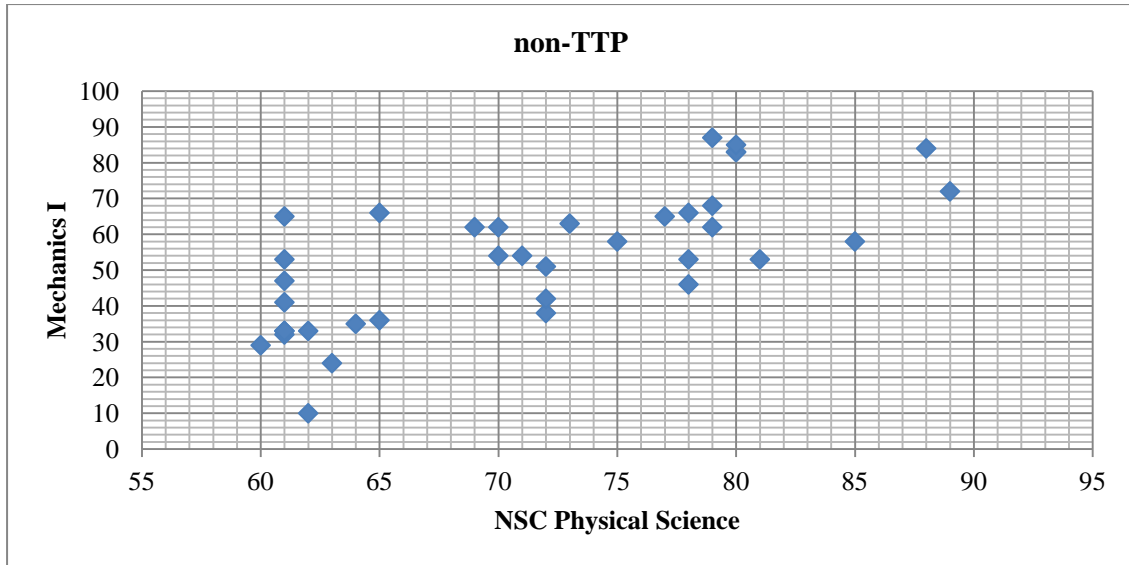
| <b>Correlations</b> |        |         |
|---------------------|--------|---------|
|                     | ex-TTP | non-TTP |
| Maths - Maths       | 0.63   | 0.74    |
| PhysSc-Mech I       | 0.54   | 0.72    |
| PhysSc-Mech II      | 0.47   | 0.83    |
| PhysSc-Physics      | 0.52   | 0.83    |

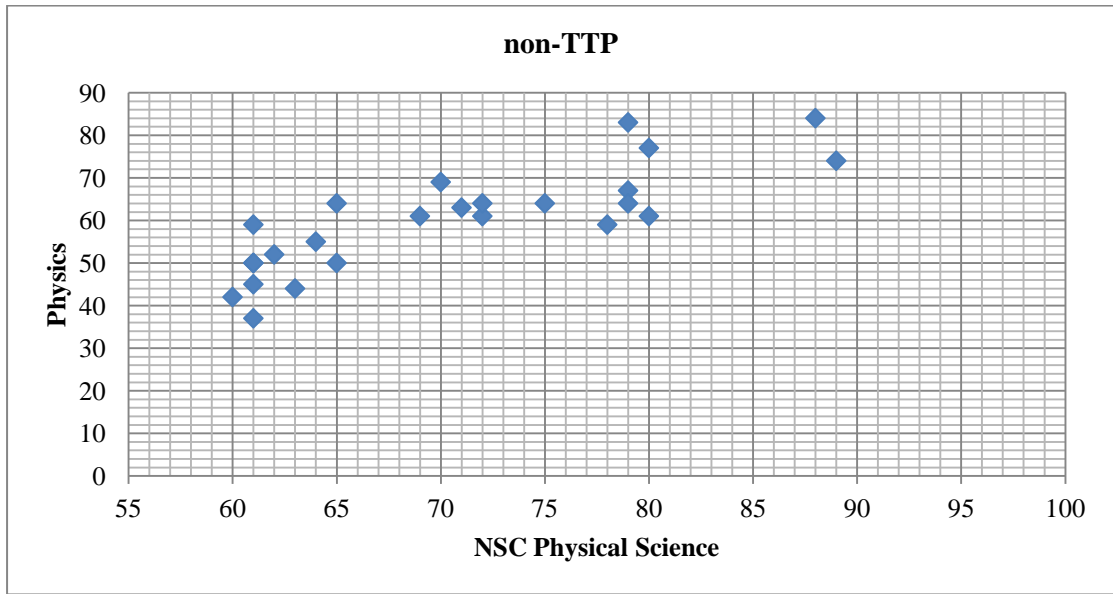
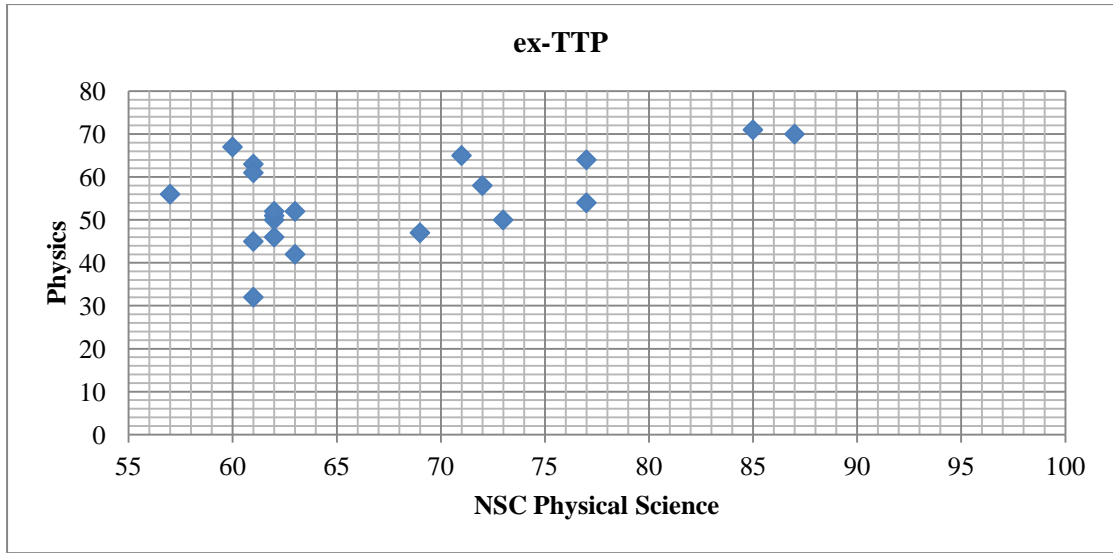
The table above shows that the ex-TTP students had lower linear correlations between the NSC results and the Wits results than did the non-TTP students. The students all started with similar NSC results, so these correlations show that, overall, the ex-TTP students have marks which are more scattered and less linear than the marks that the non-TTP students have.

The following scatter plots show that there are individuals who passed despite being in the lowest achiever group of the NSC results, and individuals who failed despite being in the middle or highest achiever group of the NSC results.

**Figure 4.9 Scatterplots: NSC vs Wits Subjects**







**Pass Rates by Branch of Engineering****Table 7 Pass Rates by Branch of Engineering**

| <b>Maths</b> | <b>ex-TTP</b>          |                  | <b>non-TTP</b>         |                  | <b>cohort</b>          |                  |
|--------------|------------------------|------------------|------------------------|------------------|------------------------|------------------|
|              | <b>No. of Students</b> | <b>Pass Rate</b> | <b>No. of Students</b> | <b>Pass Rate</b> | <b>No. of Students</b> | <b>Pass Rate</b> |
| Biomed       | 1                      | 0                | 0                      |                  | 32                     | 53               |
| Chem         | 12                     | 83               | 8                      | 87.5             | 124                    | 80               |
| Civil        | 1                      | 0                | 7                      | 57               | 154                    | 66               |
| Elec         | 3                      | 67               | 6                      | 83               | 154                    | 54               |
| Mech         | 1                      | 0                | 7                      | 86               | 146                    | 65               |
| Aero         | 4                      | 75               | 1                      | 100              | 95                     | 69               |
| Indus        | 1                      | 0                | 0                      |                  | 38                     | 50               |
| Met & Mat    | 5                      | 20               | 3                      | 67               | 70                     | 48               |
| Mining       | 9                      | 56               | 5                      | 40               | 171                    | 51               |
| <b>TOTAL</b> | <b>37</b>              | <b>57</b>        | <b>37</b>              | <b>73</b>        | <b>949</b>             | <b>61</b>        |

| <b>Mech I</b> | <b>ex-TTP</b>          |                  | <b>non-TTP</b>         |                  | <b>cohort</b>          |                  |
|---------------|------------------------|------------------|------------------------|------------------|------------------------|------------------|
|               | <b>No. of Students</b> | <b>Pass Rate</b> | <b>No. of Students</b> | <b>Pass Rate</b> | <b>No. of Students</b> | <b>Pass Rate</b> |
| Biomed        | 1                      | 100              | 0                      |                  | 33                     | 59               |
| Chem          | 12                     | 83               | 8                      | 63               | 121                    | 74               |
| Civil         | 1                      | 0                | 7                      | 86               | 163                    | 63               |
| Elec          | 3                      | 33               | 6                      | 83               | 156                    | 53               |
| Mech          | 1                      | 0                | 7                      | 100              | 155                    | 67               |
| Aero          | 4                      | 75               | 1                      | 0                | 88                     | 68               |
| Indus         | 1                      | 0                | 0                      |                  | 39                     | 54               |
| Met & Mat     | 5                      | 20               | 3                      | 33               | 66                     | 36               |
| Mining        | 9                      | 33               | 5                      | 0                | 193                    | 45               |
| <b>TOTAL</b>  | <b>37</b>              | <b>51</b>        | <b>37</b>              | <b>65</b>        | <b>1008</b>            | <b>58</b>        |

| <b>Mech II</b> | <b>ex-TTP</b>          |                  | <b>non-TTP</b>         |                  | <b>cohort</b>          |                  |
|----------------|------------------------|------------------|------------------------|------------------|------------------------|------------------|
|                | <b>No. of Students</b> | <b>Pass Rate</b> | <b>No. of Students</b> | <b>Pass Rate</b> | <b>No. of Students</b> | <b>Pass Rate</b> |
| Biomed         | 1                      | 0                | 0                      |                  | 31                     | 61               |
| Civil          | 1                      | 0                | 7                      | 43               | 160                    | 67               |
| Elec           | 3                      | 33               | 5                      | 80               | 152                    | 53               |
| Mech           | 1                      | 0                | 7                      | 86               | 153                    | 62               |
| Aero           | 4                      | 75               | 1                      | 100              | 87                     | 66               |
| Indus          | 1                      | 0                | 1                      | 100              | 39                     | 49               |
| Mining         | 9                      | 22               | 4                      | 25               | 184                    | 47               |
| <b>TOTAL</b>   | <b>20</b>              | <b>30</b>        | <b>25</b>              | <b>64</b>        | <b>806</b>             | <b>58</b>        |

| Physics | ex-TTP          |           | non-TTP         |           | cohort          |           |
|---------|-----------------|-----------|-----------------|-----------|-----------------|-----------|
|         | No. of Students | Pass Rate | No. of Students | Pass Rate | No. of Students | Pass Rate |
| Biomed  | 1               | 100       | 0               |           | 30              | 80        |
| Civil   | 1               | 100       | 7               | 71        | 168             | 89        |
| Elec    | 3               | 100       | 5               | 80        | 153             | 80        |
| Mech    | 1               | 0         | 7               | 86        | 149             | 87        |
| Aero    | 4               | 100       | 1               | 100       | 81              | 86        |
| Indus   | 1               | 100       | 1               | 100       | 38              | 84        |
| Mining  | 9               | 56        | 4               | 100       | 182             | 71        |
| TOTAL   | 20              | 75        | 25              | 84        | 801             | 82        |

The number of students in each branch in each of the two samples is small so that it is not possible to make meaningful comparisons of pass rates for each branch. One thing that is apparent is that for each subject as a whole, the pass rate for the ex-TTP students is lower than both the non-TTP students and the cohort. The best pass rate for the ex-TTP students is for Physics and the worst is for Mechanics II. The ex-TTP Mechanics II pass rate of 30% is the only one of the ex-TTP and the non-TTP groups less than 50%.

Of the ex-TTP students who wrote the Mathematics, Mechanics II and Physics examinations, 6 passed all three subjects, 4 passed two subjects, 5 passed only one subject and 5 did not pass any of the three subjects. Of the ex-TTP students who wrote the Mathematics and Mechanics I examinations, 10 passed both subjects, 2 passed one and 5 did not pass either of the two subjects.

#### 4.4 Summary

The Grade 10 and NSC results show that the ex-TTP students were able to attain higher scores in the NSC after the TTP intervention. These results also show that the NSC marks attained for Mathematics in particular, were very high.

The Wits data shows that the lowest achiever group in each subject had a failing mark. The middle achiever group of the ex-TTP students had mixed results, with some failing marks and some passing marks, as did the non-TTP students. However the class boundaries of the non-TTP middle achiever group show that the sub-group's results were, in general, better than the ex-TTP students' results in the same sub-group. The ex-TTP top achiever groups all had lower upper boundaries than the non-

TTP students. All of the top achiever sub-groups had passing marks.

The trends shown in the comparison of the NSC and Wits results show clearly that for both the ex-TTP and the non-TTP students, the Wits results are lower than the NSC results, and that the drop for the lowest achiever group is greater than the drop for the highest achiever group.

The mark distributions of the Wits subjects show that the mode of the ex-TTP students is in a lower decile than the mode of the cohort and of the non-TTP students. The frequency distribution histograms also show that the mark distributions do not follow a normal distribution.

The means for all the subjects show that although the means of the ex-TTP students for four of the five subjects are lower than the cohort means, and the non-TTP students have a higher mean than that of the cohort for all the subjects, at the 5% level of significance, the only significant differences occur between the ex-TTP students and the cohort and also the ex-TTP students and the non-TTP students for Mechanics I and Mechanics II.

For all the Wits subjects, the correlation between NSC marks and Wits marks for the ex-TTP students is lower than for the non-TTP students. The scatterplots for the ex-TTP students show that all the students who got over 95 for their NSC mathematics passed the Wits Mathematics course; all the students, bar one, who got over 75 for their NSC Physical Science passed Mechanics I and Mechanics II; and that all the students who got over 70 for their NSC Physical Science passed Physics.

The pass rates show that the ex-TTP students have a lower pass rate than the non-TTP students and the cohort for all subjects, with the pass rate for Mechanics II being particularly disappointing. It can also be seen that only 16 of the 37 ex-TTP students passed all the subjects that they attempted.

The overall academic proficiency of the ex-TTP students appears to be less than that of the non-TTP students and the cohort. However, there are several ex-TTP students who have excelled in the Wits subjects.

## **Chapter 5: Focus B: Competencies and Habits of Mind**

### **5.1 Introduction**

The focus of this chapter is to determine if there is evidence that, in their Engineering Mathematics, Physics and Mechanics courses at Wits, the ex-TTP students are being required to use Competencies and Habits of Mind encountered in the TTP Mathematics and Science courses.

The Competencies and Habits of Mind foregrounded by the TTP will be identified, and evidence of Competencies and Habits of Mind present in the teaching material and teaching methods used in the Wits Mathematics, Mechanics and Physics courses will be found. The overlap of Competencies and Habits of Mind present in both situations will be identified.

### **5.2 Competencies and Habits of Mind in the TTP**

The Mathematical and Scientific competencies in the PISA document (OECD 2006) and the Habits of Mind identified by Couco et al were introduced to the TTP teachers at a workshop in 2006. Subsequent to the workshop, teachers designed the curricula for each of the subjects taught by the TTP. The teachers were required to incorporate the Competencies and Habits of Mind into short-term and long-term objectives. (Curriculum Report for the Targeting Talent Project 2007, p.1). The short-term objectives evolved into lesson plans. (ibid).

At the end of 2007, a retrospective analysis of the year was done. It consists of four parts: (a). A list of the overarching ideas that formed the focus in the development of the curriculum for the learners; (b). A critical discussion regarding the overarching ideas for learners; (c). A list of the overarching ideas that formed the focus in the development of the curriculum for the teachers; and (d). A critical discussion regarding the overarching ideas for teachers. Only parts (a). and (b). will be discussed. The overarching **ideas** forming the focus in the development of the learners' curriculum are:

- i. Optimization in the development of the interrelated skills that need to be developed for each discipline.
- ii. Strengthening of the use of English as an integral part of concept formation in each discipline.
- iii. Enriching the existing curriculum that learners are exposed to during normal school time.
- iv. Creating a classroom culture that is conducive to active participation as a learner as part of a shared learning community.
- v. Assessing progress in the different disciplines.

In the critical discussion of Idea (i), it is noted that “[t]he different disciplines managed to link some of the most important interrelated skills (conjecturing, linking experimentation with deduction, using tables and graphs to interpret and communicate information, use the computer in a specific and general context) into a network of competencies.” (p.4). Conjecturing and linking experimentation with deduction are habits of mind (Cuoco et al, 1996), whereas using tables and graphs are competencies, as is the use of the computer.

### **5.2.1 Mathematics**

The PowerPoint presentation by the Mathematics teachers (Curriculum Report for the Targeting Talent Project 2007, Addendum 2- Mathematics) shows that they followed the PISA document closely. The organisation of the domain that is assessed, the overarching ideas of Shape and Space, Change and Relationships, Quantity and Uncertainty, the process of Mathematisation and the Competency Clusters (p79ff OECD 2006) were all specifically presented as slides. The contexts used for the lessons were Transformations and 3-D solid objects. The teachers incorporated the following Competencies into the lessons: From the Reproduction Cluster, standard representations and definitions, routine computations, routine procedures, and routine problem solving. (Slide 15). From the Connections Cluster, modelling, standard problem solving translation and interpretation, and multiple well defined methods. (Slide 16). From the Reflections cluster, complex problem solving and posing, reflection and insight, original mathematical approach, multiple complex methods, and generalisations. (Slide 17).

(See Chapter 2 for a detailed account of Competency Clusters.)

In the Curriculum Report for the Targeting Talent Project 2008, the Competencies from the PISA document are not specifically referred to, but those identified in the Reflections Cluster as noted above, are evident in the objectives for the Mathematics lessons given during the March contact session. The objectives for the theme of the first set of lessons are “To create awareness that the same quantity may be calculated in quite different ways; to allow learners to propose criteria for judging the advantages and disadvantages of different methods; to affirm personal mathematical freedom with respect to choice of method.” (The Learning Trajectory, 2008, p.1).

An additional objective was added for the second theme used in the lessons, i.e. “To develop modelling skills”. (The Learning Trajectory, 2008, p.2). Modelling is one of the eight mathematical competencies identified in the PISA document. Modelling involves “structuring the field or situation to be modelled; translating reality into mathematical structures; interpreting mathematical models in terms of reality; working with a mathematical model; validating the model; reflecting, analysing and offering a critique of a model and its results; communicating about the model and its results (including the limitations of such results); and monitoring and controlling the modelling process.” (OECD, 2006, p.97). It is clear from the notes for the lessons that these attributes of modelling were used to generate the lesson plan.

In 2009, the focus of the first contact session was trigonometry. The Competencies from the Reproduction Cluster were the basis of the first half of the program, but elements of the other two clusters are brought in to each outcome. For example, Outcome (iii) was “Introducing the CAST rule and the concept of vertical and horizontal reduction to create co-terminal angles that will allow us to evaluate expressions where reduction formulae are explicitly stated, as well as those questions where the learner must decide on which reduction was appropriate.” (Targeting Talent – Mathematics program conceptualisation, 2009, p.6). The Reproduction Cluster Competencies are present in the introduction of the CAST rule and in the evaluation of expressions where the reduction formulae are explicitly stated, Competencies from the Connections Cluster are implied by the concept of vertical and horizontal reduction, and Competencies from the Reflections Cluster are implied by requiring the learner to decide on which reduction was appropriate.

The second half of the program required Competencies from mainly the Connections and Reflections Cluster. For example, in “Introducing all trigonometric identities and applying them to the concepts learned thus far.” (ibid), Competencies from the Connections Cluster are implied.

In the introduction to the report entitled Targeting Talent-Mathematics program conceptualisation, the Habits of Mind that underlie the whole program from 2007 to 2009 are listed as “algebraic reasoning, reasoning by continuity, defining, proof reasoning, proportional reasoning, reasoning with invariance and spatial visualisation.”. (p. 1). On page 3 of the same document, where Contact Session 3 is described, the focus being Number pattern, the following statement identifies the Habit of Mind specific to the lessons: “Thus cycling the work through the frame of exploring number, extracting structure, working with structure and moving the structure through generalisations becomes the underlying habit of mind that this work fosters.”. On page 4 of the document, another Habit of Mind is identified as the one which “fosters the formation of rules that represent functions.”. The use of intellectual chants is present in the Financial Mathematics lessons. The learners were encouraged to use ‘simple interest is based on the original amount only’ and ‘compound interest is based on the balance’ as the discourse for the initial exploration of the topic. On page 9 of the document, it is suggested that identifying different methods of solving problems and then discussing the appropriateness of the methods should become a habit of mind for both the teachers and the learners.

### **5.2.2 Science**

The PowerPoint presentation done by the science teachers at the planning meeting in 2006 was entitled “Synergy Workshop”. (Curriculum Report for the Targeting Talent Project 2007, Addendum 3 Science). It firstly describes a theoretical framework for curriculum design based on the Scientific Competencies described in the PISA document, which shows that Contexts (personal, social and global), Knowledge (of science and about science) and Attitudes (towards science and the environment) all impact on Competencies. The Competencies are identified as: Identifying Scientific Issues, Explaining Phenomena Scientifically and Using Scientific Evidence to make and communicate decisions. Knowledge is described as having two aspects to it, knowledge *of* science (physical systems, living systems, earth and space systems, and

technology systems) and knowledge *about* science (how scientists get data, and how scientists use data). This description of scientific knowledge is based on the discussion on page 22 of the PISA document.

In the introduction to the report on the Science Program in the Curriculum Report for the Targeting Talent Project 2009, the author identifies the overarching focus of the program as “the learning of processes for developing scientific literacy. The processes included the following:

- Retrieving information
- Forming a broad general understanding
- Developing an interpretation
- Reflecting on and evaluating the content of a text
- Reflecting on and evaluating the form of a text”

These processes are Competencies similar to the Scientific Competencies in the PISA document, which are listed as Identifying scientific issues, Explaining phenomena scientifically, and Using scientific evidence (OECD, 2006, p.29).

During the contact session in mid-year 2008, the students used a CAD tool called ‘Solid Edge’ to design a scooter. The main aim of this session was to improve visualisation of 3-D objects, which is a Habit of Mind crucial to engineering.

During the contact session in September 2008 the concept of motion was taught. The main Habit of Mind that was emphasised is being able to use and move between verbal and graphical representations of data.

### **5.3 Wits Mathematics documents**

The Wits Mathematics documents that are available are the Course Guide (School of Mathematics, 2010) and the book “First Year Engineering Mathematics” (Ridley, 2001) which is called a study guide in the Course Guide.

There are no direct references to any Competencies or Habits of Mind in the Course Guide, and none can be inferred from the information in the Guide.

In the Introduction to the Ridley book, the author points out that most branches of engineering continue with mathematics courses until the third year, and that “the objective of the mathematics courses for engineering is to develop the mathematical

knowledge and skills required for practical applications.” (p.iii). This objective can be likened to the mathematisation cycle described in the PISA document (OECD, 2006, p.95). The mathematisation cycle starts with a real-life problem which is translated into a mathematical problem for which mathematical solutions are found. The mathematical solutions are then applied to the real situation, taking into account the limitations implied by the real-life situation and the limitations of the solution. The Mathematisation process requires the student to have mathematical competencies. Since the course under consideration is a first year course, the mathematics is relatively basic and there are not many real-life scenarios which are solvable with the mathematics available to the students. However, there many instances the theory is followed by examples from engineering to which the theory can be applied, for example the application of the first and second derivatives to the motion of a piston (Ridley, 2001, p.30). These examples require some if not all, of the steps of mathematisation, and thus the application of mathematical competencies. The tutorial questions in the book (Ridley, 2001) have been classified according to their nature: the drill exercises, theory-based questions and questions that need greater insight. The questions in the drill exercises and the theory-based questions fit into the Reproduction and Connections Competency Clusters, while the enrichment exercises fall into the Reflection Competency Cluster described in the PISA document (OECD, 2006).

#### **5.4 Wits Physics documents**

The Physics Course Outline and Information document (School of Physics, 2010a) contains oblique references to Scientific and Mathematical Competencies. The document refers to using mathematics, which is a cognitive process implied in the scientific competencies (OECD, 2006, p.29), and to “developing the student’s approach to problem solving”, which can be construed as a blanket term for many of the Mathematical and Scientific Competencies.

The Course Objectives for the Physics course are:

- Deep understanding of the basic physical principles;
- An awareness of the important role these principles play in engineering and technology;
- A culture of lifelong learning and interest in science and technology;
- Ability to model physical systems of limited complexity;

- Ability to analyse physical situations using mathematics of an appropriate level;
- Problem solving involving open ended thinking and not simply mechanical routines;
- An appreciation of and ability to conduct experiments, make observations and measurements and analyse, interpret and derive information from measured data.

The School of Physics has identified some “essential actions” by the performance of which students are assessed. The list is as follows:

1. Demonstrate recognition of the essential factors in a physical system and of the physical principles or processes that are involved;
2. Define, interpret and apply concepts and laws;
3. Demonstrate understanding of problems presented in verbal, numerical or diagrammatic form, and know how to proceed;
4. Develop and execute a strategic problem solving approach appropriate to each problem;
5. Select and apply appropriate techniques, such as diagrams depicting the key features of a problem;
6. Formulate the appropriate equations and perform the mathematical solution;
7. Present numerical results with appropriate significant figures and units; check working by orders of magnitude, physical reasoning, dimensional analysis;
8. Communicate logic and detail of solution;
9. Relate mathematical processes to physical phenomena (integration, differentiation, vector products);
10. Reason physically, draw analogies, relate theory to commonplace engineering situations;
11. Conduct experiments, make observations, carry out measurements and interpret data.

The objectives and essential actions listed above are identifiable as competencies, some of which are clearly mathematical competencies and some of which are specific to Physics.

Redish and Smith (2008) point out that physicists and mathematicians have different

ways of using equations. They claim that when using mathematics in science, a blending of the understanding of the rules of mathematics with an understanding of the physical world is apparent. (p.302).

The PISA document (OECD, 2006) was prepared for testing 15-year-olds, and the Scientific Competencies were identified from the perspective of students having a general background in science, i.e. the competencies refer in a general way to physical systems, living systems, earth and space systems and technology systems. (The Scientific Competencies are Identifying Scientific Issues, Explaining Phenomena Scientifically and Using Scientific Evidence to make and communicate decisions.) Trying to specifically identify Scientific Competencies in the Physics objectives and essential actions as per the PISA document is thus not a fruitful exercise. Checking for Mathematical Competencies is fruitful, although the point made by Redish and Smith (2008) should be borne in mind – mathematics competencies used in physics will be slightly different to those used in mathematics.

*Thinking and Reasoning* is necessary in order to analyse physical systems using mathematics (5<sup>th</sup> bullet point in the Objectives). Problem solving of a non-routine nature (6<sup>th</sup> bullet point in the Objectives) and analysing, interpreting and deriving information from measured data (7<sup>th</sup> bullet point in the Objectives) also require thinking and reasoning.

*Argumentation*, which involves, amongst other things, “possessing a feel for heuristics (“what can happen and why?”)” (OECD, 2006, p.97), is clearly needed for problem solving which is mentioned extensively in both the Objectives and Essential Actions.

*Communication*, which involves expressing and understanding mathematical content in various forms, is evident particularly in Essential Actions 3 and 8, but underlies Essential Action 7 and others.

*Modelling* underlies all the problem solving required in the Physics syllabus.

*Problem posing and solving* is the basis of the Physics syllabus, and the Essential Actions spell out what is required from the students with regard to problem solving.

*Representation* which “involves decoding and encoding, translating, interpreting and distinguishing between different forms of representation of mathematical objects and situations; ...” is needed for example in Essential Actions 5 and 6.

*Using symbolic, formal and technical language and operations* is a Competency particularly applicable to Essential Actions 7, 8 and 9.

*Use of aids and tools* is a competency that is applicable to Essential Action 11, since the use of computers and laboratory equipment is essential to creating and manipulating data.

The Physics textbook that is analysed is “Physics for Scientists and Engineers with Modern Physics” (7<sup>th</sup> Edition) by Jewett and Serway (2008). The main objectives of the book are: “to provide the student with a clear and logical presentation of the basic concepts and principles of physics and to strengthen an understanding of the concepts and principles through a broad range of interesting applications to the real world.” (p.xvii). In order to achieve these objectives, emphasis is placed on “sound physical arguments and problem-solving methodology.” (p.xvii). Practical examples from engineering, chemistry, and medicine are used in the text and in the exercises at the end of the chapters. There is a section at the beginning of the book addressed to the student in which, amongst other things, the necessity of understanding concepts and principles, and of extending understanding beyond merely being able to do calculations correctly is motivated. Problem Solving is also highlighted, and advice about how to be successful problem solver is given. (p.xxixff). In Chapter 2 of the book an algorithm for problem-solving is suggested. This algorithm is strongly reminiscent of the Mathematisation cycle (and its concomitant Competencies) as described in the PISA document. The four steps of the problem-solving algorithm are: Conceptualise, Categorise, Analyse and Finalise. In each example in the text, the four steps are foregrounded, as shown in the copy of an example shown on page xviii. Students are also encouraged to do their own experiments using everyday articles as well as laboratory facilities, thus encouraging the Habit of Mind of experimenting. The tutorial questions at the end of each chapter are graded as straightforward, intermediate and challenging, and some questions are designed to develop symbolic reasoning and others ask for qualitative reasoning. The grading of the questions is in line with the three competency clusters identified in the Mathematics section of the PISA document (OECD, 2006), although one needs to read the competencies with the awareness that physics and mathematics are not completely synonymous. The questions that ask for symbolic and qualitative reasoning are in line with the course objectives for the physics course.

The authors Jewett and Serway clearly intend students to attain a Physics Literacy encompassing competencies and knowledge.

## 5.5 Wits Mechanics documents

The Mechanics Course Outline and Information document (School of Physics, 2010b) lists the main aims of the course as developing the following “essential skills:

- Modelling static and dynamic mechanical systems of limited complexity in two dimensions;
- Analysing mechanical situations using calculus, geometry and trigonometry;
- Developing problem-solving skills that enable you to develop and execute strategies for tackling non-stereotype cases.”

This list of aims is much shorter than the list of Physics course objectives, but the first and the last one are also in the Physics list. The middle one is phrased a bit inadequately – algebra is also needed in mechanics. This is again a list of competencies that are common in name to both Mathematics and Physics, but the modelling, mathematics and problem-solving skills required by mechanics are different to those found in mathematics due to the different knowledge base of the two subjects.

The mechanics course uses two textbooks – one for statics and one for dynamics. Both books, “Engineering Mechanics Statics” and “Engineering Mechanics Dynamics”, both 12<sup>th</sup> edition, are written by Hibbeler, and are purchased as a set. As in the TTP documents, one of the emphases of the books is the understanding of concepts, to which end visualisation aids, both static and dynamic, have been provided on compact discs, promoting the Habit of Mind of visualisation. The other emphases are analytical and problem-solving skills, which, as in the Physics text book, can be linked to the mathematisation process and its concomitant Competencies. The tutorial questions at the end of each section of each chapter are graded as fundamental problems, problems and conceptual problems, again linking to the Conceptual Clusters of the PISA document.

Coloured boxes headed “Procedure for Analysis” are found before the set of worked examples of each chapter in the books. The boxes contain algorithms and procedures specific to the topic of the chapter. Many of the points could be interpreted as Habits of Mind, although there is no actual reference to the notion of Habits of Mind, for example, “Establish a position coordinate  $s$  along the path and specify its fixed origin and positive direction.” (Hibbeler, 2010b), p.9) is an example of using an algorithm.

## 5.6 Interviews with TTP teachers and Wits lecturers

Three TTP teachers and three Wits lecturers were interviewed. They were shown the abbreviated list of Habits of Mind and asked if they would comment on which of the items in the list they felt they were using or that they could recognise as attributes that they were striving to pass on to their students. They were also asked if they were conscious of trying to pass on the Habits of Mind, even if they did not call them by that name.

The first part of the list is shown in Table 8.

**Table 8            Characteristics of General Habits of Mind**

**Characteristics of general habits of minds (Cuoco, Goldenberg, & Mark, 1996)**

Students should be:

Pattern sniffers, Experimenters, Describers, Thinkers, Inventors, Visualizers, Conjecturers, Guessers

All six interviewees agreed that students should be all of the things listed, but it was a general consensus that time constraints imposed on teachers, lecturers and students did not enable the type of teaching that could lead to students being able to exercise these habits freely. The TTP teachers felt that the Habits of Mind were part of the way that they taught the students and as such were not clearly documented. The Wits lecturers agreed that one Habit of Mind, namely students being experimenters, was the Habit of Mind least likely to happen, especially in the Wits mathematics course. The reasons given for this being the least possible Habit of Mind to foster, were that the class was too big and the time-constraints of the syllabus did not allow for experimentation.

The second part of the list, shown as Table 9, is specific to mathematics, but the physics lecturer also commented on it because he is aware that much of physics involves mathematics and mathematical logic.

**Table 9            Habits of Mind Specific to Mathematics**

**Habits of mind specific to mathematics (Cuoco, Goldenberg, & Mark, 1996)**

Talk big and think small (from the general to the specific)

Talk small and think big (from the specific to the general)

Use functions

Use multiple points of view

Mix deduction and experiment

Push the language

Use intellectual chants

### **Algebraic approaches to things**

a. like a good calculation    d. break things into parts

b. use abstraction            e. extend things

c. use algorithms            f. represent things

### **Geometric approaches to things**

a. use proportional reasoning    e. worry about things that change

b. use several languages at once    f. worry about things that do not change

c. use one language for everything    g. love shapes

d. love systems

The above list was given to the teachers and lecturers without much explanation.

Individuals were left to interpret the statements in their own way but where individuals asked for clarification, some detail of what is implied by the statements was given.

Most of the interviewees asked for clarification of the statements “Push the language”, “Use intellectual chants”, “use several languages at once” and “use one language for everything”. After discussion the interviewees all agreed that the concept of mathematical language was not overtly discussed, but that where terminology specific to mathematics was encountered, the teachers and lecturers alerted the students to the language usage.

The lecturers pointed out again that class size and time constraints militated against them being able to encourage mixing deduction and experiment and extending things, whereas the TTP teachers said that these were habits of mind that they were trying to foreground for the students. The mathematics lecturers pointed out that there is no geometry per se in the Wits mathematics syllabus, but that the habits of mind listed apply to mathematical problem solving in general.

All of the teachers and lecturers agreed that the rest of the habits of mind in the list are present in the way they try to present the material to the students.

The last part of the list is shown as Table 10.

**Table 10 Cross-disciplinary Habits of Mind**

| <b>Cross-disciplinary General Habits of Mind (Costa, 2000)</b>  |
|---|
| <p>Persisting; Managing impulsivity; Listening with understanding and empathy;<br/>           Thinking flexibly; Thinking about thinking (metacognition); Striving for accuracy;<br/>           Questioning and posing problems; Applying past knowledge to new situations;<br/>           Thinking and communicating with clarity and precision; Gathering data through all senses;<br/>           Creating, imagining, innovating; Responding with wonderment and awe;<br/>           Taking responsible risks; Finding humour; Thinking interdependently; Remaining open to continuous learning.</p> |

The TTP lecturers found this list to be very representative of what they were doing in the Program. The Wits lecturers felt that the following statements did not really apply to what they do in their courses: “Gathering data through all the senses; Creating, imagining, innovating; ... Taking responsible risks”, but that the other statements are things which they would very much like to see as characteristics of their students. The Wits lecturers were somewhat sadly aware that very few of the students had these habits of mind and that they, as lecturers, were not really doing an effective job of encouraging students to have these habits of mind.

## **5.7 Summary**

The TTP curriculum was based on the PISA document which clearly elucidates Competencies and on the concept of Habits of Mind. The annual TTP reports show that the program was able to prepare material which foregrounded a way of approaching learning which should have given students the ability to develop and use the Competencies and Habits of Mind which underpin the learning material. The curriculum content was presented in such a way that students could improve their content knowledge, but was mainly used to try to inculcate strategies of learning in the form of Competencies and Habits of Mind that are more effective than those they had been using at school.

The Wits documents show that the Mathematical Competencies that are elucidated in the PISA document and the Habits of Mind listed in Table 3 (p.19) can be identified in the analytical and problem solving skills that students are expected to develop in all three of the Wits subjects. However, there is not much overt teaching or guidance from the lecturers on how these skills should be acquired. Algorithms for problem

solving are given or implied in the reading the material, while lecturers advocate that attending lectures and doing the tutorials will enable students to enhance their skills. Consultation with tutors and lecturers is articulated as the best way for students who are struggling to obtain help with developing their skills.

The interviews with the TTP teachers and the Wits lecturers showed that the TTP teachers were much more aware of the task of teaching students in a way which inculcated Competencies and Habits of Mind into their approach to learning than the Wits lecturers were. The Wits lecturers saw the Habits of Mind as a wish list that it would be really nice for students to have, but not as something that was at the forefront of the learning which they were striving to elicit from the students.

## **5.8 Conclusion**

The Competencies listed by the PISA document and the TTP teachers differ slightly in that the TTP teachers have adapted the PISA Competencies in such a way that the Competencies are suitable for achieving the learning outcomes of the TTP lessons. The Wits documents and lecturer interviews indicate that there are no obvious differences between the Competencies identified by the TTP and the PISA document, and the Competencies that can be identified in the Wits teaching and learning milieu. The Habits of Mind that were presented to the TTP teachers are only sporadically referred to in the documents, but the teachers confirmed in interviews that they form part of the didactics of the TTP classrooms. Habits of Mind can be teased out of the Wits text books, and the Wits lecturers could identify many of the Habits of Mind as being present in the methods they encouraged students to use when striving for mastery of the subjects.

## **Chapter 6: Focus C: Study Techniques**

### **6.1 Introduction**

In this chapter, study techniques aimed at helping students cope with tests and examinations that can be inferred from the teachers and teaching material of the TTP, Mathematics, Physics and Mechanics courses will be identified. Also, the questionnaires which were filled in by nine of the ex-TTP students and which were aimed at identifying the preparations they make for tests and examinations will be discussed.

### **6.2 TTP Mathematics Study Techniques**

Except for the last of the TTP Mathematics contact sessions before the NSC examinations, there was no evidence in the Curriculum Reports or the course material of the Mathematics, Science or Molecular Literacy that overt advice had been given to the students about how to prepare for tests and examinations, but a personal communication from one of the TTP teachers confirmed that guidance was given during the contact sessions throughout the programme.

In the last of the TTP mathematics contact sessions before the NSC examinations, students were given past NSC examination papers to work through. They were expected to complete any questions that were not done in class in their own time before the next session. In the “Targeting Talent-Mathematics program conceptualisation” report from the end of 2009, the lecturers note that students were experiencing a sense of achievement and mastery of the topics they had concentrated on while doing the past papers. The students were “very confident about the work that they have completed in these papers.” (p10). The practice of using past papers to consolidate knowledge and the expectation from the lecturers that the students would complete all the questions on the papers and discuss their successes and difficulties

can be seen as an example of a study technique which could be used when studying for success in a test or examination.

A survey of the Curriculum Reports from 2007 to 2009 shows an emphasis on how to help students cope with the particular topics in terms of their Competencies that are contained in their content knowledge and their grasp of concepts, and their Habits of Mind. The Mathematics teachers from the TTP state that “[t]he program has been very successful at introducing critical thinking in our learners, and this has made them very excited and engaged in their learning. ... In the targeting talent program they were expected to think for themselves, to respect the opinions of their peers and to engage with and challenge those ideas that they did not fully understand or agree with.” (Targeting Talent-Mathematics program conceptualisation, 2009, p10). In accordance with the aim of the TTP that students should be successful at university, the students were expected to be able to use critical thinking, independent thinking and discussion with peers and lecturers at university in order to help them cope successfully with the academic challenges they encountered.

An interview with a TTP teacher highlighted that it is almost an irony that the TTP is so successful at improving the students’ abilities to do well at school that the students can actually spend less time preparing for school tests and examinations than they did before being part of the programme. This is a possible disadvantage for students when they get to university because they are used to finding the work relatively easy and could initially underestimate the time and type of preparation needed for university tests and examinations. At university, there is a large volume of work covered in a short time compared to the duration and volume of work at school. During the interview with the TTP teacher, s/he pointed out that it is not possible to simulate the large volume of work and thus give TTP students experience of how to cope with it.

### **6.3 Study Techniques in the Wits Mathematics Course**

Interviews with the Mathematics lecturers at Wits revealed that they concentrated on encouraging students to do all of the tutorial examples as the term progressed and to use past papers for revision, but the interviews did not show any evidence of lecturers advising students about how to plan their revision. The Mathematics lecturers said that the tutorial sessions during the week are meant to be used for students to ask

tutors (who are lecturers or post graduate students) for help with tutorial questions that they have not been able to complete after trying them at home, but the lecturers that I interviewed said that most students came to the tutorial not having started on the tutorial questions relevant to that week. This implies that students are not working efficiently and on the right aspects of the course in their own time. The tutorial questions are intended to help students grasp the concepts and the skills needed for successfully mastering the contents of the course, particularly for the tests and examinations, but also because the courses are fundamental to the understanding of courses in subsequent years of the degree.

The School of Mathematics believes that students should have access to resources in addition to the prescribed textbook, lectures and tutorials in order to maximise their potential to pass the tests and examinations. A Resource Centre has been created in the School of Mathematics where a range of text books is available so that students can have access to explanations different to the one given in lectures, and so that students can find examples for extra practice. There are also post-graduate students available at certain times for consultations. Lecturers say that they make a point of encouraging students to use the Centre whenever they need extra help either with their tutorial questions or with test and examination preparation.

The Mathematics text book by Ridley is designed to “develop the mathematical knowledge and skills required for practical applications. Thus pure theory is kept to a minimum, and understanding of the principles and facility with the techniques are of prime importance” (Ridley, 2001, p.iii). The book is also designed as an adjunct to the lectures so no worked examples have been included and some of the explanations are summaries of what would be given in the lectures. A book of tests and examinations for the preceding four years is issued to the students at the beginning of each year, which is a clear indication that not only the textbook and lecture material are meant to be used for test and examination preparation. The author attended several lectures near the end of the second semester. It was observed that lecturers use the lecture time to present full or partial solutions to particular questions from the past papers, and that they stress the importance of practicing the techniques by doing all the questions from the tutorials that are in the text book and all the questions on the past papers.

The Mathematics Course Guide (School of Mathematics, 2010) lists three on-line textbooks available to students. The cost of access is included in the fees paid to the

university by the students. Not one of the students interviewed mentioned using the on-line books. There is also a list of 11 recommended textbooks, all designed for Engineers, and all available in the libraries and the Resource Centre. Only one of the students interviewed mentioned using other textbooks for more examples to practice on.

The Mathematics Course Guide (School of Mathematics, 2010) gives the following guidelines for the amount of time students are expected to spend working on Mathematics outside of lecture times: “You are expected to spend between one and two hours of your own time for every hour of lecture time, on working through the lecture notes, lecture examples, tutorial and past test and exam questions. This amounts to spending between 5 and 10 hours a week studying the material. This is YOUR responsibility.” (p2). There is also a clear explanation of what is expected from the students for the tutorial classes, and an explanation of the tutorials offered by the Academic Development Unit (ADU) of the Faculty of Engineering and the Built Environment. Two of the students interviewed mentioned attending the ADU tutorials. There is ample evidence that the School of Mathematics has endeavoured to put sufficient resources in place to ensure that students work consistently during term time and have access to assistance with preparation for the tests and examinations. The study techniques implied here are that students should do all tutorial work on time, use all resources available and ask for help when it is needed.

#### **6.4 Study Techniques in the TTP Science Course**

There is very little documentary evidence of students being coached on study techniques, but, as is the case for Mathematics, the teachers indicated that verbal advice was given, and that in the last contact session of the Science programme past NSC question papers were given to the students to do. The past papers served to highlight which topics had not yet been done at the schools and to give students practice in answering the type of question that would be encountered in their final examinations. Group work was encouraged, and students were encouraged to continue working in groups when they returned to school.

#### **6.5 Study Techniques in the Wits Physics and Mechanics Courses**

The Physics course outline indicates that there are minimum attendance requirements for tutorials and laboratory sessions and that there are spot tests and other assessments

during tutorials. Both conditions imply that students must keep up to date with their work. The Physics lecturer said, during the interview, that students are expected to have a textbook because the lecturers make specific reference to the relevant sections in the textbook and expect students to be familiar with the material. The lecturer explained the tutorial arrangements as follows: Students are put into subgroups of 4, and tutors are assigned to groups of about 25 students. Students are expected to have attempted all the tutorial questions given to them for each week before they come to the tutorial. They are expected to get help with problematic questions from their peers and from the tutor. The study techniques that are implied by the rules and arrangements are those of understanding concepts, practising problem-solving and keeping up to date with the work. The lecturer said that past Physics test and examination papers are available from the Wits Library and that students are encouraged to make use of them.

The Mechanics course outline states “Students are expected and encouraged to attend all lectures. Experience shows that students who do not attend lectures regularly are likely to fail. ... Homework problems will be assigned before the tutorial sessions and students are expected to attempt all problems in advance.” (Mechanics course outline, 2010, p.3). Tutorial questions are designed to be of the same standard and the same general format as students will encounter in the tests and examinations so as not to disadvantage students by surprising them with question with levels of difficulty and types that they are unfamiliar with. (Interview with lecturer).

The study pack and CD-ROM that come with the Mechanics textbook contain extra explanations and examples that are specifically aimed at improving study skills. However, the lecturer said that the students are not specifically directed to use the study pack or CD-ROM, and the students that were interviewed made no mention of using anything other than the prescribed textbook and their lecture notes. Past mechanics examination papers are available from the Wits Library, and students are encouraged by the lecturers to make use of them.

## **6.6 Commonalities in TTP and Wits Study Techniques**

The common features of the TTP and the Wits Mathematics, Physics and Mechanics courses are that study techniques for test and examination preparation are not spelt out

by the teachers and lecturers, but are implied by the advice to be thorough in completing the classwork and to use past papers to consolidate knowledge and to reveal the level of content knowledge and process skills that the student has prior to the test or examination. Past papers can thus be used by the student for diagnosing areas of weakness and areas of strength and for familiarising the student with the type of question that will be asked.

Interviews with TTP teachers and Wits lecturers show that also common to the TTP and Wits is the stress on the importance of understanding the concepts so that the students do not resort to mindless formulaic approaches to the solution of problems.

## **6.7 Study Techniques used by the ex-TTP Students**

The questionnaires answered by nine of the ex-TTP students give some insights into how these students prepare for tests and examinations.

### **6.7.1 Time spent on preparation**

Four of the students start revising for tests a week before the test, three of them three days before and two of them one or two days before. For the exams, the longest time mentioned was 2 weeks before the examination, and the shortest time was two days. One student waited for lectures to stop before preparing for the examination, and one stated that s/he studied when the opportunity presented itself.

There was an almost equal split between students who neglected their other subjects and those who did not when it came to preparing for a test. Those who neglected their other subjects gave the high level of difficulty of Mathematics and Mechanics as a reason for concentrating almost solely on those subjects before a test, while the awareness that it is not wise to get left behind in other subjects is given as a reason for not neglecting other subjects by the second group of students.

Four of the students said that they had prepared a study timetable for the examinations, but two confessed that they had not been able to stick to it. One student had a mental plan but did not write it down, and one student said that s/he made a timetable “sometimes”. Three of the students did not make any timetables.

The previous three paragraphs describe how students deal with the logistics of when to study. There is no clear indication that all the students were using a preparation

pattern familiar to them as a group of ex-TTP students. They seem to have made decisions about when to start preparing and how much planning is needed, but there is no evidence of what they based these decisions on.

### **6.7.2 Use of resources**

Lecture notes in Mathematics are meant to expand on and add to the Ridley textbook. In Physics and Mechanics the lecture notes are available on WebCT and anything extra that the lecturer wants to add is specifically highlighted during lectures (Interview with Physics lecturer) as not being in the available notes. Students are not expected to take copious notes in Physics lectures. In Mechanics, the lectures follow the prescribed textbook very closely, but students are encouraged to use other textbooks for enrichment and alternative explanations (Interview with Physics lecturer).

Students fall into two main groups – those who use a textbook as a first option, and use lecture notes as clarification of the textbook, and those who use the lecture notes as a first option for revising concepts and as a source of what is going to be important in tests and examinations, while using the textbook as a reference for clarification. One obviously capable student said that s/he did not take notes in class but still managed to pass both Mathematics and Mechanics!

The majority of the students interviewed said that they redid tutorial questions and worked through past papers in preparation for tests and examinations. All of them looked up the answer to each past-paper question as they finished it. This indicates that none of the students used the past papers to practice writing a whole test or exam. There is no clear indication that those who redid tutorial questions during revision benefitted more than those who used other methods.

Of the nine ex-TTP students that were interviewed, only three used the Mathematics Resource Centre, and then only for revision and help with past papers. One of these students mentioned that she did not know of the existence of the resource centre until late in the second semester. The lack of knowledge of the existence of the Resource Centre is surprising given that the Mathematics lecturers said that during lectures they encourage students to use the Centre. Two other students mentioned that they attended ADU classes and thus did not need to use the Centre. This is possibly an indication that some students take a decision not to use the Centre.

All of the students interviewed, except one, said that they consulted the lecturers or tutors outside of tutorial time.

### **6.7.3 Study Groups**

The TTP encourages students to work in groups, both during the contact time at Wits and also when they are doing their regular school work (Interview with TTP teacher). Only two of the nine students interviewed said that they worked consistently in groups at Wits, three said they sometimes worked in groups and four said that they always worked on their own. Two of those who did not work in groups said in the interview that they had tried working in a group but found that the other members of the group were never at the same place with the work as themselves, and they felt that a lot of time was wasted because there was not enough common ground. The groups that did meet usually met on the weekends and spent 5 or 6 hours together. The groups reviewed lecture notes, either before or during the meeting, in order to remind themselves of concepts and to attempt to grasp those concepts not understood. They also attempted and discussed lecture examples, tutorial questions and questions from past papers.

### **6.7.4 Other strategies**

The last question in the first section of the questionnaire (dealing with preparation for tests) asked the students to mention any other things that they do to prepare for tests and examinations. Only one student mentioned using MyMathLab. The others felt that every thing that they do had been covered by the questions thus far.

The last question of the second section of the questionnaire asked if students used any different tactics in preparing for an examination as opposed to preparing for a test. All of them indicated that the only difference was that they spent longer preparing for the examination.

### **6.7.5 Summary of Student Responses**

The evidence gathered from the questionnaire and interviews indicates that students have definite strategies which they use when preparing for test and examinations, and that two of these (group work and use of past papers) were used during their time with the TTP and while at Wits. Group work by the ex-TTP students seems not to have been as consistent at Wits as it was during the TTP phase. The interviews show that

the ex-TTP students claimed to have put in many hours of preparation for the tests and examinations.

## **6.8 Summary**

The study techniques encouraged by the TTP teachers were that the students worked in groups during contact time and whilst they were at school between contact times, that the students use the critical and independent thinking skills introduced to them at the TTP contact sessions and that the students use past examination papers to prepare for the examinations.

The Wits lecturers encouraged students to keep up to date with tutorial questions assigned each week, to ask peers, lecturers and tutors for help, to use resources of extra material available to them, and to use past test and examination papers in preparations for tests and examinations.

Some of the ex-TTP students interviewed worked in a group with other students in order to keep up to date and to prepare for examinations. All used past papers during preparation for tests and examinations. Some made use of extra resources such as the Resource centre and ADU classes. All consulted lecturers outside of lecture and tutorial time.

## **Chapter 7: Conclusions and Recommendations**

### **7.1 Introduction**

In this chapter the main findings from the data gathered for each of the Foci will be discussed by drawing together the results from the previous chapters. The results and conclusions will be related to the literature that informed the formulation of the research question. It should be borne in mind that one of the aims of the TTP is to enable students to succeed at university.

The overarching research question is:

To what extent has the three year intervention provided by the TTP enabled students to succeed in the first year of the Engineering degrees for which they are registered?

### **7.2 Focus A: Academic Proficiency**

All of the students had NSC results which indicated that they should have been able to cope academically at Wits. The 37 ex-TTP students who completed the academic year have shown that only 16 of them were able to learn and retain material in such a way that they could cope successfully with the demands of assessment and thus obtain a passing mark for all their subjects.

The first trend analysis shows that the ex-TTP students were able to improve their marks from Grade 10 to the NSC, possibly implying that the TTP had been effective in helping them attain entrance to the university.

The second trend analysis shows that once they were being tested at university, some students coped adequately and others did not. Amongst those who did not cope well, there is a clear indication that their class marks (obtained from class tests and

assignments) are higher than their examination marks. This could be an indication that some students have examination preparation techniques that are inadequate.

The third trend analysis shows that the NSC results are much higher than the Wits marks. This is possibly an indication that the preparations for the NSC examinations did not equip all of the students well enough for the level of difficulty of the Wits subjects.

The mark distributions also show that there is a relatively large percentage of the students who did not cope with the Wits academic demands. This is also reflected in the analysis of the means and standard deviations where the group of students who did not cope well dragged the mean down to below the mean of the cohort for four of the five subjects, and caused the sample to have a lower standard deviation than the cohort. The lower standard deviation implies that the ex-TTP students are more tightly clustered around their mean than the cohort is around its mean. This implies that most of the ex-TTP students have marks which are close to the lower mean mark.

The scatterplots show that, in general, it is the ex-TTP students who have very high NSC marks that are most likely to pass the Wits subjects. The plots also show that there are students with relatively low marks in NSC Mathematics and Physical Science who have passed the Wits courses. This suggests that these students have found an effective way of coping with the academic demands of the Wits courses. There are also ex-TTP students with relatively high NSC marks who have failed the Wits courses. This may imply that their academic preparedness was not as good as is needed and that the Competencies and Habits of Mind that they have developed were inadequate for the demands of the examinations. It is a noteworthy concern that the NSC results do not seem to be able to discriminate between candidates who will be successful at university and those who will not.

The pass rates show that the ex-TTP students had fewer passes than the non-TTP students even though they all started with comparable NSC results. A possible cause for the lower performance of the ex-TTP students is that the many years of less than ideal schooling outweighed the advantages of the TTP intervention.

### **7.3 Focus B: Competencies and Habits of Mind**

The TTP program was designed using the PISA document (OECD, 2006) as a framework, thus Competencies and Habits of Mind were built into the way the curriculum was presented. The students were expected to be able to transfer the Competencies and Habits of Mind to their tertiary education. The successful ex-TTP students may well have consciously or sub-consciously made the transfer, while the unsuccessful students may not have had the Competencies and Habits of Mind well embedded.

The Wits subject documents showed that the Competencies identified by Niss (2002) and the PISA document (OECD, 2006) are implied by the objectives of the courses and by the arrangement of the tutorial material. The tutorial questions are graded from basic to complex, implying that students will develop their problem solving abilities as they master the simpler questions and progress to the more complex ones. There are no explicit references to Habits of Mind but some of the problem solving techniques which are touched on in the text books are similar to Habits of Mind. The successful ex-TTP students may have been able to pick up on the similarity of presentation, while the unsuccessful ones may have been unable to recognise the similarities to their TTP experiences.

### **7.4 Focus C: Study Techniques**

The main study techniques advocated by both the TTP teachers and the Wits lecturers were keeping up to date, completing all the tutorials and assignments and using past test and examination papers to practice answering the type of questions likely to be encountered.

Some of the ex-TTP students spent many hours working in groups, but others felt that group work did not maximise their learning and preferred to study on their own. The ex-TTP students who were interviewed spent relatively short times preparing specifically for tests and examinations. There is evidence that the study techniques used by the ex-TTP students worked for some students and not for others. There must be other factors such as the effectiveness of the actual learning techniques or social and emotional coping strategies which affected the success of the students.

## **7.5 Conclusions**

The TTP was undoubtedly a factor which assisted students to attain the NSC results necessary for entrance to Wits. Sixteen of the 37 ex-TTP students were able to use coping mechanisms which enabled them to pass all the subjects considered in this research, but the rest of them were not able to achieve total success despite their sterling efforts. The TTP has partially succeeded in its goal of helping students to be successful at university, but the ambition of the TTP is for all ex-TTP students to get a university degree, so some additional interventions are needed.

Students entering university for the first time encounter many non-academic factors which impinge on their ability to realise their full potential (Felder et al, 2000). Since all of the ex-TTP students had the academic credentials for success (as defined by the Wits entrance requirements), these other factors are probably causing some of them to stumble.

## **7.6 Recommendations**

The time available for the TTP during the school year is very limited, nonetheless the curriculum seems to be achieving the goal of helping students to get university entrance on the basis of their NSC results. The depth of the learning strategies conveyed to the students during the TTP needs to be addressed so that students are better equipped to cope at university.

The TTP goes a long way in enabling talented students with disadvantaged backgrounds to achieve their full potential, but it is possible for the advantages of the program to be brought to full fruition by mentoring at university.

The ex-TTP students at university probably need some mentoring for at least their first year. Many students get off to a bad academic start and are unable to do well enough in later tests to enable them to attain a pass mark (personal observation), so early mentoring is vital.

It is suggested that ex-TTP students be mentored by university staff members who have been involved in the TTP. The mentoring could start off with a lot of help being given to students in the first quarter. The help could become more occasional in

nature as the year progresses. The aim of the mentoring should be to nurture the student from a state of confusion and/or insecurity to becoming an independent learner. Mentors would need to be able to assist students with academic as well as non-academic coping mechanisms. Skills such as time management, study skills, financial management, and coping with social and family demands would need to be engendered in the students.

### **7.7 Future Assessment of the Effectiveness of the TTP program**

In the main, current ex-TTP students are using techniques and resources available to them and yet many are unsuccessful. I believe it is crucial to interview both successful and unsuccessful ex-TTP students in order to establish why some students are coping and others are not. This could lead to changes in the TTP tactics so that the aim of all ex-TTP students being successful at university is realised.

Continued analysis of academic performance would give an indication of whether any changes and/or additions to the TTP program are successful.

## Appendix 1: Calculating Wits Points

The rating system used by Wits and known as the students' Wits Points is described below. The document can be found on the Wits web site.

Wits uses a number of selection procedures to select candidates for degrees. These procedures include a rating system, admission points score (APS), questionnaires, selection tests, interviews, auditions or written assignments.

### The rating system

You can work out your points using the tables below.

### 1. If you matriculated in 2008 or after (National Senior Certificate NSC), use this system

The National Senior Certificate (NSC) is the current school-leaving qualification. It is based on the current curriculum for Grades 10 to 12. If you are matriculating in 2010, this is the school leaving certificate you will receive if you pass your exams.

Wits tabulates the points score for all subjects on the following basis:

- English is the LOLT (language of learning and teaching) at Wits; a requirement is that English must be taken either as Home Language or the LOLT or as 1st Additional Language. The minimum APS for English is 4 (50 - 59%). Foreign students presenting with English as 2nd Additional Language will have the option of a foreign conditional exemption and / or English proficiency tests.
- Maths is compulsory for all numerate programmes in Engineering and Built Environment, Commerce, Law and Management, and Science.
- Maths Literacy will be accepted by Law, Education and Humanities (except Speech and Hearing).
- Wits does not distinguish between designated vs non-designated subjects when calculating the admission point score (APS)
- The Faculty of Health Sciences allows limited entry with Maths Literacy.

| NSC Scale of Achievement | NSC%  | Wits APS | Wits APS% | Wits APS for Maths & English | Wits APS for Life Orientation | Wits APS for Other subjects |
|--------------------------|-------|----------|-----------|------------------------------|-------------------------------|-----------------------------|
| 7                        | 80-99 | 8        | 90-100    | 8+2=10                       | 4                             | 8                           |
| 6                        | 70-79 | 7        | 80-89     | 7+2=9                        | 3                             | 7                           |
| 5                        | 60-69 | 6        | 70-79     | 6+2=8                        | 2                             | 6                           |
| 4                        | 50-59 | 5        | 60-69     | 5+2=7                        | 1                             | 5                           |
| 3                        | 40-49 | 4        | 50-59     | 4                            | 0                             | 4                           |
| 2                        | 30-39 | 3        | 40-49     | 3                            | 0                             | 3                           |
| 1                        | 0-29  | 0        | 30-39     | 0                            | 0                             | 0                           |
|                          |       |          | 0-29      | 0                            | 0                             | 0                           |

### Designated Subjects - NSC

- Agric Sciences
- Visual Art
- Economics
- History
- Life Sciences
- Maths Literacy
- Dramatic Art
- Accounting
- Engineering Graphics & Design
- Religion Studies
- Physical Sciences
- Consumer Studies
- Music
- Business Studies
- Geography
- Information technology
- Mathematics
- All official languages and a number of non- official languages

### Engineering and the Built Environment

| Programme   | Minimum faculty admission requirements & Scale of Achievement             | Likely acceptance level   | Selection procedures   |
|---|---|---|--|
| Bachelor of Science in Engineering (4years)<br><a href="#">BSc(Eng)</a> | English HL or 1st Add Lang - 4<br>Mathematics - 5<br>Physical Science - 5 | <i>Branch of:</i> Electrical 36 and above<br><i>Branch of:</i> Mechanical 36 and above<br><i>Branch of:</i> Aeronautical 36 and above<br><i>Branch of:</i> Civil 36 and above<br><i>Branch of:</i> Industrial 36 and above<br><i>Branch of:</i> Metallurgy 30 and above | Acceptance is dependent on final NSC results and applicants may be required to complete a biographical questionnaire and profession related exercises.<br><br>Note: Due to the |

|  |  |   |  |
|--|--|---|--|
|  |  | <p><i>Branch of:</i> Chemical 42 and above<br/> <i>Branch of:</i> Mining 30 and above.<br/>                 Provided that: A Maths pass at NSC Scale of Achievement level 5 (except for Mining where a pass at NSC Scale of Achievement level 4 is acceptable), a Physical Science pass at NSC Scale of Achievement level 5 and an English language pass at NSC Scale of achievement level 5 is obtained.</p> | <p>limited number of places available, meeting the likely acceptance level does not guarantee admission. Selection will be based on final NSC results.</p> |
|--|--|---|--|

## **Appendix 2: Data Sources**

### **A2.1 Focus A: Academic Proficiency**

NSC Mark Lists      Wits University Academic Registrar

Mathematics Mark Lists      School of Mathematics

Mechanics Mark lists      School of Physics

Physics Mark list      School of Physics

Grade 10 Marks      SETMU

### **A2.2 Focus B: Competencies and Habits of Mind and Focus C: Study Techniques**

TTP Curriculum Report 2007

TTP Curriculum Report 2008

The Learning Trajectory 2008

Targeting Talent – Mathematics program conceptualisation 2009

Targeting Talent – Science program conceptualisation 2009

MATH1014 Mathematics I Course Guide

First Year Engineering Mathematics by J.N. Ridley 2001

PHYS1014 Physics IE Course Outline and Information

Physics for Scientists and Engineers with Modern Physics, 7<sup>th</sup> Edition, by J.W. Jewett and R.A. Serway 2008

PHYS1015 Applied Mechanics Course Outline and Information

Engineering Mechanics Statics, 12<sup>th</sup> Edition, by R.C. Hibbeler

Engineering Mechanics Dynamics, 12<sup>th</sup> Edition, by R.C. Hibbeler

Digital Recordings of interviews with TTP teachers and Wits lecturers

Digital Recordings of interviews with ex-TTP students

Questionnaires from ex-TTP students

## A2.3 Interview Schedules and Questionnaires

### A2.3.1 Interview Schedule: Targeting Talent Program Teachers

Please describe the thinking, learning and study skills you encourage the TTP students to develop and use.

Are you consciously trying to engender Habits of Mind such as in the following table:

| <b>Characteristics of general habits of minds (Cuoco, Goldenberg, &amp; Mark, 1996)</b>   |
|---|
| <p>Students should be:</p> <p>Pattern sniffers, Experimenters, Describers, Thinkers, Inventors, Visualizers, Conjecturers, Guessers</p>   |
| <b>Habits of mind specific to mathematics (Cuoco, Goldenberg, &amp; Mark, 1996)</b>   |
| <p>Talk big and think small (from the general to the specific)</p> <p>Talk small and think big (from the specific to the general)</p> <p>Use functions</p> <p>Use multiple points of view</p> <p>Mix deduction and experiment</p> <p>Push the language</p> <p>Use intellectual chants</p> |

**Algebraic approaches to things**

- a. like a good calculation
- b. use abstraction
- c. use algorithms
- d. break things into parts
- e. extend things
- f. represent things

**Geometric approaches to things**

- a. use proportional reasoning
- b. use several languages at once
- c. use one language for everything
- d. love systems
- e. worry about things that change
- f. worry about things that do not change
- g. love shapes

**Cross-disciplinary General Habits of Mind (Costa, 2000)**

Persisting; Managing impulsivity; Listening with understanding and empathy;  
 Thinking flexibly; Thinking about thinking (metacognition); Striving for accuracy;  
 Questioning and posing problems; Applying past knowledge to new situations;  
 Thinking and communicating with clarity and precision; Gathering data through all senses;  
 Creating, imagining, innovating; Responding with wonderment and awe;  
 Taking responsible risks; Finding humour; Thinking interdependently; Remaining open to  
 continuous learning.

What do you do in your classroom in order to help students become effective learners?

### A2.3.2 Interview Schedule: Wits Mathematics and Physics Lecturers

Please describe the thinking, learning and study skills you encourage the Engineering students to develop and use.

Are you consciously trying to engender Habits of Mind such as in the following table:

|   |
|---|
| <p><b>Characteristics of general habits of minds (Cuoco, Goldenberg, &amp; Mark, 1996)</b></p>  |
| <p>Students should be:</p> <p>Pattern sniffers, Experimenters, Describers, Thinkers, Inventors, Visualizers, Conjecturers, Guessers</p>   |
| <p><b>Habits of mind specific to mathematics (Cuoco, Goldenberg, &amp; Mark, 1996)</b></p>  |
| <p>Talk big and think small (from the general to the specific)</p> <p>Talk small and think big (from the specific to the general)</p> <p>Use functions</p> <p>Use multiple points of view</p> <p>Mix deduction and experiment</p> <p>Push the language</p> <p>Use intellectual chants</p> |
| <p><b>Algebraic approaches to things</b></p> <p>a. like a good calculation    d. break things into parts</p> <p>b. use abstraction            e. extend things</p> <p>c. use algorithms              f. represent things</p>  |

**Geometric approaches to things**

- a. use proportional reasoning
- b. use several languages at once
- c. use one language for everything
- d. love systems
- e. worry about things that change
- f. worry about things that do not change
- g. love shapes

**Cross-disciplinary General Habits of Mind (Costa, 2000)**

Persisting; Managing impulsivity; Listening with understanding and empathy;  
Thinking flexibly; Thinking about thinking (metacognition); Striving for accuracy;  
Questioning and posing problems; Applying past knowledge to new situations;  
Thinking and communicating with clarity and precision; Gathering data through all senses;  
Creating, imagining, innovating; Responding with wonderment and awe;  
Taking responsible risks; Finding humour; Thinking interdependently; Remaining open to continuous learning.

What do you do in your lectures and tutorials in order to help students become effective learners?

### A2.3.3 Questionnaire given to ex-TTP students

This questionnaire is designed to inform the researcher about the techniques that you use when you study for Mathematics and Physics tests and exams.

1. Look at the question below. It comes from page 81 in First Year Engineering Mathematics by J.N. Ridley:

D20. A long hollow trumpet is formed by rotating the curve  $y = \frac{1}{x}$  between the points where  $x = 1$  and  $x = X$  about the  $x$  axis.

Find the volume and the curved surface area.

Show that as  $X \rightarrow \infty$  the volume tends to  $\pi$  but the curved surface area tends to  $\infty$ .

Is there a contradiction? Observe that in order to paint the entire inner surface it is sufficient to pour  $\pi$  cubic units of paint into the trumpet.

Think about how you would answer the questions. Write down your answers in the space below and over the page. Show your working and diagrams, and then write down the thinking processes you used as you decided what to do, and as you worked out the answers. Explain what techniques you use when you get stuck. You can write notes where you have written your answer to clarify what you want to say about how you were thinking and/or you can write a description below your working. The researcher is interested in the thinking processes you use. If you are aware that you are using problem solving techniques that you used during your time with the TTP teachers, please identify the techniques in your description of your thought processes.

2. The researcher is interested in what you do when you are preparing for a class test in Mathematics or Physics. Fill in the table below as accurately as you can:

|   |  |
|---|--|
| 1. How many days before the test do you start your revision?  |  |
| 2. Do you neglect your other subjects to concentrate on studying for the test?  |  |
| 3. What do you use the lecture notes for?   |  |
| 4. Do you redo your tut questions?  |  |
| 5. Do you answer old test papers?   |  |
| 6. If you do use past papers, when do you check your answers – after every question or at the end of the test?            |  |
| 7. Do you work in a study group or on your own?   |  |
| 8. If you work in a group,<br>a) how many are in your group?  |  |
| b) Describe the other members of your group: how many are ex-TTP students like you are? How many are not ex-TTP students? |  |
| c) How often do you meet as a group and how long do you spend working together?   |  |
| d) Describe what you do in your group in order to learn the work for the test.  |  |
| 9. Do you use the Maths Resource Centre? If you do, what do you do there?   |  |
| 10. Do you consult your lecturer (or a  |  |

|   |  |
|---|--|
| tutor) when you cannot understand the work?                                     |  |
| 11. Describe any other things that you do in order to be prepared for the test. |  |

If there is not enough space in the table for some of your answers, please use the space below, or an additional page if necessary!

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