

**AN INVESTIGATION OF WHETHER THE  
INTRODUCTION OF AN E-MASTERY SYSTEM  
FOR QUANTITY SURVEYING STUDENTS AT  
THE DURBAN INSTITUTE OF TECHNOLOGY  
IMPROVES KEY COMPETENCIES**

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## ABSTRACT

Students' poor performance in the quantity surveying course at the Durban Institute of Technology appeared to be due to the lack of basic key competence in certain key areas such as mathematics and arithmetic. The students' weaknesses in key competencies were validated in the pre-tests with both the 2003 and 2004 cohorts where few students, only two out of sixteen and one out of eight respectively, displayed mastery in these key areas.

Mastery learning was identified as a methodology to use for helping students because it benefited slow and fast learners alike. This study investigates the use of an e-mastery learning system to help students improve their competence in some of the key areas identified.

An experiment was conducted, using the 2003 fourth-year quantity surveying students as a control group and the 2004 fourth-year quantity surveying students as the experimental group. The control group took a pre-test, were subjected to a face-to-face intervention and then they took a post-test. The experimental group took the same pre-test, were exposed to a mastery learning system, which was then followed by the same post-test.

The results of this experiment showed that the mastery learning intervention helped the students, but not to the extent expected by the author. The experiment indicated that the e-based system was only marginally more helpful than the face-to-face intervention which the control group received. This quantitative aspect of the experiment was hampered by small sample sizes and was further constrained by difficulties in accessing the e-mastery system. Following this outcome, a qualitative study was undertaken, in the form of semi-structured interviews, to ascertain why the e-based system was not as successful as expected. Although the quantitative analysis indicated that the e-based system was more helpful, the interviews revealed the underlying problems were related to access to the e-based system and students' limited computer literacy skills.

The conclusion drawn from these findings is that an e-based mastery learning system would help students improve their key competencies provided the computer literacy problems and access problems were solved, the mastery learning system was more comprehensively developed, and that the students were motivated enough to devote themselves to using the system on a regular basis.

## DECLARATION OF ORIGINALITY

I declare that this dissertation is my own work and that all sources I have used or quoted have been indicated and acknowledged by means of complete references.

A handwritten signature in blue ink, appearing to read 'E.G. Frank', written over a horizontal line.

E.G. Frank

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Durban

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## Key Terms

**E-mastery** means a mastery learning system that is presented electronically by a computer

**E-Based** means a computer and internet based system

**Technikon** is a tertiary level education and training institution in South Africa similar to a polytechnic

**Matriculation** is Grade 12 final school examination giving the grades and subject combinations needed for tertiary study

**World Wide Web or “Web”** is a popular protocol used to publish and access information on computer servers linked to the internet.

**Department** is the Department of Construction Management and Quantity Surveying at the Durban Institute of Technology.

**D.I.T.** is the Durban Institute of Technology

**School** refers to primary and secondary education institutions (grades 1-12) in South Africa

# Chapter 1: Introduction

## 1.1 Introduction

Through-put of students completing their diploma at the Department of Construction Management and Quantity Surveying at the Durban Institute of Technology (D.I.T.) has declined steadily in recent years. Through-put is the percentage of students who complete a three-year diploma within five years compared to the number who enrolled in the programme at first year level. For example, 39% of the students who enrolled in 1998 eventually graduated by 2003 and 27% of those who enrolled in 1999 graduated by 2004. This dissertation considers reasons for the declining through-put rate and investigates the introduction and application of an intervention that aimed to improve through-put by improving the acquisition of key competencies. This intervention took the form of an e-mastery learning system that addresses some basic maths concepts.

## 1.2 National and institutional context

The National Diploma in Building (N.Dip Building) can be studied at many technikons in South Africa including the D.I.T. where this project was carried out. To register, a student requires a matriculation certificate (SA Qualifications Framework level 4) with elementary achievement (30% or higher) in English first language and mathematics. The diploma comprises 18 subject credits obtained over three years. On completion, the student may elect to do a B.Tech degree, specialising in either quantity surveying or in building management. The B.Tech is a one year, honours-level (SA Qualifications Framework level 7) course that comprises six subjects.

The courses are presented in English. Many students at the D.I.T. have either Zulu or Xhosa as their mother tongue. In a study of readability problems in mathematics, Prins and Ulijn (1998: 141) noted that

at school level about 80% of all pupils are African. Secondary education is either in English or Afrikaans which means that most secondary school students are second language learners.

Prins and Ulijn (ibid) explain that linguistic and cultural factors contribute to the African students' difficulties in mathematics.

In a study investigating successful classroom practices in school mathematics in black South African schools, Nkhoma (2002: 103) reports that “only 1 in 312 students who enter the school system leaves with physical science and mathematics as final year subjects”, and then he expands on various reasons why black students are poor at mathematics, compared to whites, Indians and coloureds<sup>1</sup>. He points to teacher-centred instruction that is authoritarian in style and promotes rote learning with little or no understanding, as the main reason for poor performance. Many of the national diploma courses require a thorough grounding in mathematical concepts. Weakness in mathematics is therefore likely to jeopardise the chances of students completing the courses successfully.

The award of degrees in mathematics is in decline in South Africa. A survey of 15 South African universities by Engelbrecht and Harding (2003:17) found the number of mathematics graduates had declined by 32% between 1990 and 2000. The authors also noted international trends that suggest “the mathematical sciences worldwide are in crisis”.

### **1.3 Departmental context**

The Department of Construction Management and Quantity Surveying at D.I.T. carried out a basic numerical skills test on 106 students in 2002 (Appendix A). The test results provided an indication of students’ weaknesses in basic numerical skills. The test required students to do simple addition, subtraction, multiplication and division calculations mentally, without the use of calculators. The test contained 198 calculations and the time limit was 10 minutes. The results of the test revealed that the students needed much more time than allowed. Although it was expected that a high school graduate should be able to complete 99 calculations in 10 minutes, the group’s average was 56 calculations completed in 10 minutes. The slowest student only managed to complete four sums in ten minutes. The level of inaccuracy was also very high with, for example, 11% of the group unable to give the correct answer for the question requiring them to subtract 8 from 19.

At third-year level, in the author’s experience, students frequently confuse operations such as multiplication with addition, or units such as millimetres with metres, which indicate fundamental gaps in their mathematical ability. Students have been able to progress

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<sup>1</sup> Nkhoma (2002) uses the terms “black”, “white”, “Indian” and “coloured” to describe different racial groups. In South Africa, the term “coloured” is used to describe people of mixed race.

through two years of study at a tertiary institute despite being unable to apply key fundamental mathematical concepts.

To assess basic mathematical ability, the author tested a class of 14 fourth-year quantity surveying students on simple mathematics concepts, derived from the grade 12 Exit Level Learning Outcomes prescribed by SAQA (South African Qualifications Authority, n.d.). The test required the students to calculate surface areas, perimeters, diameters and perpendicular heights of geometric shapes, and to do conversions such as millimetres to metres or litres to cubic metres. There was no time limit to the test. Nine out of the fourteen fourth-year quantity surveying students did not achieve a score of 80% or higher. In view of the centrality of such basic mathematical concepts to the quantity surveying course, the competency level is set at 80%. (Refer to Pilot Test Results in Appendix B)

The department's basic numerical skills test and the author's own findings regarding the students' maths abilities are supported by an evaluation conducted at 500 secondary schools in South Africa where

the overall results for Grade 9 learners on the mathematics instrument indicate that the majority of learners performed extremely poorly. The mean score of the national sample was 21% and the district mean scores ranged from 18% to 27%. (Kanjee, et al, 2001:129)

Kanjee et al's research acknowledges that students are also weak in literacy. Many students use English as their second or third language, and often their command of English is weak and their vocabulary is limited.

### **1.3.1 Contract between student and department**

Once a student has been accepted in a learning programme, the tertiary institute has entered into a contract to teach the student. Notwithstanding the students' poor mathematics schooling, cultural and language handicaps, once the student has registered, the department concerned has to adapt to the level of the student, and provide the necessary support. This is confirmed by Zaaïman, van der Flier and Thijs's (2000: 1) study "Selection as Contract to Teach at the Student's Level", where they emphasise that: "Selection has to be followed by adequate support for selected students to succeed in their study programmes."

### **1.3.2 The need for an intervention**

As discussed above, there is a national and international decline in maths ability. Large numbers of students are critically weak at maths, which affects their tertiary performance. In the author's classroom experience with third and fourth-year students it was evident that students were weak in applying mathematics skills in a quantity surveying context such as calculating areas and volumes correctly and using units of measurement correctly. Many students have difficulty in reading drawings correctly and translating two-dimensional representations on paper into the three-dimensional structures they represent. The department is experiencing a decline in through-put. Furthermore, the department is obliged to support its students. All these factors point to the urgency to institute an intervention that can support students by improving their maths ability and their vocabulary.

A mastery learning programme was proposed and developed that addressed five content areas in the intervention.

### **1.4 The intervention**

The following content areas for the mastery programme were identified from the results of the tests described above and the experience of departmental lecturers:

- Mental arithmetic – to improve mental addition, subtraction, multiplication and division
- Mathematics – to be able to calculate the properties of geometric shapes, such as length and volume, to calculate percentages, and convert units of measurement
- Measuring – to be able to calculate areas and volumes from technical drawings and use and convert units of measurement in a quantity surveying context
- Drawing interpretation – to understand plans, elevations and sections, be able to translate from a two-dimensional plan and elevation presentation to a three-dimensional isometric view, or translate from an isometric view to a plan and elevation presentation
- Vocabulary – to be competent in mathematical and construction terminology

The mastery programme was intended to be web-based and aimed to provide tutorial material, assessment and formative feedback to students. The programme was designed for students to be able to access it in their own time and at their own pace. Developed as a self-study package, it was intended to be less demanding of the lecturer's time.

The mental arithmetic and mathematics content areas ran on the web-based learning environment, WebCT. WebCT (Web Course Tools) is used to author and manage online courses. It can be used for the purpose of distance or blended (i.e. online and face-to-face) teaching and learning. D.I.T. is licensed to use the system and provides training and support to lecturers through the ICT-ed Centre at D.I.T.'s Centre for Higher Education Development. The measuring content area is currently paper-based but could potentially be transferred to WebCT. Drawing interpretation is delivered and answered on paper. It could be partially automated to be delivered electronically, but would have to be answered and assessed manually.

The initial vision for the mastery programme was very ambitious. The development of the material turned out to be a considerable undertaking. A substantial amount of material was developed for the first two areas, namely mental arithmetic and mathematics. A small amount of material was developed for the measuring and drawing interpretation and very little for vocabulary.

It is important to note that this intervention was initiated prior to undertaking this study. For the purposes of the study, the findings from the mental arithmetic and the mathematics aspects of the intervention are emphasised as they are the most complete.

#### **1.4.1 Theoretical context of the intervention**

It is helpful to have a framework to understand the process of learning. For the purposes of this study, Bloom's taxonomy of educational objectives is used because it provides a clear and hierarchical system for understanding learning (Bloom, 1956). Bloom defines the "Cognitive Domain" as follows:

1. Knowledge
2. Comprehension
3. Application

4. Analysis
5. Synthesis
6. Evaluation

This taxonomy has been revised and clarified in “A Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom’s taxonomy of educational objectives”, by Anderson and Krathwohl (2001). The revised taxonomy is as follows:

- **Remember** – retrieve relevant knowledge from long-term memory
- **Understand** – construct meaning from instructional messages
- **Apply** – carry out or use a procedure in a given situation
- **Analyse** – break material into constituent parts and determine how parts relate to one another and to an overall structure or purpose
- **Evaluate** – make judgments based on criteria and standards
- **Create** – put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure

From the author’s and the department’s experiences and the various authors quoted earlier in this chapter, it is evident that students are weak on all levels of cognition including the lower three namely *remembering*, *understanding* and *applying*. This is why this intervention will focus on these three lower levels of cognition; this should provide the foundation for progressing to the higher levels of cognition.

As students progress through the course, the department attempts to build *application* and *analysis* skills on this weak or missing cognitive foundation. Some students rely on memorisation, without *understanding* or the ability to *apply*, in order to pass. Often poor assessment practice does not discriminate adequately between memorisation and the higher orders of cognition, and the student manages to pass from year to year. The weakness compounds itself since further learning is dependent upon the lower levels of cognition.

The department needs a teaching strategy that will fast-track learning in the lower domains such as *remembering*, *understanding* and *applying*. The student needs a learning strategy that will augment high school education, and support learning in these areas at tertiary



level. Although the mastery learning concept can be applied to learning at all levels of cognition, its principles have been adopted for this intervention.

Mastery learning, as explained by Guskey (1988), acknowledges that each student has his or her own pace of learning. The students work at their own pace, and only proceed to new subject material once the section is mastered. The content is ordered so that learning is progressive. An important mastery concept is that most students can succeed, provided they are given enough time and the correct conditions in which to learn.

## **1.5 The purpose of this study**

This study explores how people learn in general. Based on Bloom's orders of cognition the study investigates which lower orders of cognition are weak and how they can be strengthened in order to improve learning and improve pass rates. Mastery learning appears to be a system suited to improving learning especially in the lower orders of cognition. The study examines the use of mastery concepts and what the essential elements of an ideal mastery system should be. It then critically examines the mastery system that was used in the intervention, as well as other available systems. During the application of the electronic mastery learning system access and motivational constraints became evident at institutional level as well as at student level. These constraints are interrogated. Finally, the study considers the extent to which the introduction of a mastery learning system can improve certain basic key competencies.

## **1.6 Research questions**

The key research questions are:

### R1: How do people learn?

The literature review investigates learning theories such as the levels and order of cognition and holistic and atomistic approaches to learning as a means of establishing the theoretical context through which the study developed.

### R2: How can educators improve learning?

In order to improve on learning the literature review considers factors that facilitate learning by using strategies that help motivation, encourage deep learning as opposed to

surface learning, provide helpful feedback; language issues and learning for mastery are also considered.

R3: What are the mastery concepts and what examples of mastery learning systems could be used?

The essential elements of mastery learning course design are investigated and possible systems, including the e-mastery system used by the department, are considered.

R4: What constraints impact on the implementation of, access to and use of an e-mastery system?

An investigation of what equipment was available to students, whether they have the necessary computer skills to use computer and internet systems, what human resources are needed to run the system and what other factors existed, like personal problems might have hindered the use of an e-mastery system.

R5: To what extent did the departmental mastery system improve key competencies?

The data collection and analysis investigates the extent to which the mastery learning system helped students improve their key competencies.

## **1.7 Dissertation structure**

Chapter two presents the literature review which summarises the existing body of knowledge and research related to this field of study. It also includes examples of ways of implementing mastery learning concepts which support good learning practice and considers some existing mastery systems. Chapter three presents the mastery learning system under development in the department and highlights some of its strengths and weaknesses. Chapter four, the methodology chapter, explains the dual approach of quantitative and qualitative data collection and analysis, the methods used to collect the data and the tools used to process the data. Chapter five analyses the data collected and presents the findings of this research project. The quantitative data is analysed using two statistical methods and the qualitative data is explained and summarised. Chapter six is the concluding chapter which summarises the findings and gives indications of further research possibilities and further developments.

## **Chapter 2: Literature review**

### **2.1 Introduction**

Following on the research questions introduced in Chapter 1, this chapter reports on existing theories pertinent to this study. It first considers theories of learning. Then it explores the particular barriers to learning that are experienced by students that have English as their second or third language. Theory on how educators can facilitate learning follows. The concepts of mastery learning are introduced with a focus on mastery of mathematics, particularly in relation to specific key competencies. The section on mastery also reviews criticisms of the mastery concept. The next section illustrates the implementation of mastery concepts and learning theory in a practical context. The chapter concludes with an example of a paper-based learning system and some experiences of a medical school's attempt to convert a conventional course to an e-based course.

### **2.2 Learning theories**

#### **2.2.1 The progressive nature of levels of learning**

As mentioned in the introduction, Bloom's taxonomy of the cognitive domain and Andersen and Krathwohl's (2001) revision thereof categorises the cognitive process into six levels. Tertiary education tends to focus on the higher levels of cognition. In the quantity surveying course concerned in this study, the teaching and the assessment are aimed at the upper levels of Bloom's taxonomy of the cognitive process. Students are expected to:

- Apply: Carry out or use procedures in a given situation.
- Analyse: Separate material into constituent parts and determine how parts relate to one another and to an overall structure or purpose.
- Evaluate: Make judgements based on criteria and standards.
- Create: Put elements together to form a coherent whole; reorganise elements into a new pattern or structure. (adapted from Andersen & Krathwohl 2001: 31)

Eisner (2000: 3) states that "each subsequent level depends on the student's ability to perform at the level or levels that precede it." What is pertinent from Bloom's work is that

these higher levels of cognition are not accessible to students who do not have thorough grounding in the lower levels, which are:

- Remember: Retrieve relevant knowledge from long term memory.
- Understand: Construct meaning from instructional messages, including oral, written and graphic communication. (adapted from Andersen & Krathwohl 2001: 31)

As stated in the introduction, the department makes assumptions about the student's ability at the lower levels and teaches at the higher levels, which may explain its poor success rate.

The concept of progression in learning is important to the proposed intervention because the intervention must:

- be internally structured in a progressive way, and,
- address shortcomings in school competencies so that a student can proceed progressively through the levels of cognition

### **2.2.2 Motivation**

Learning is closely linked to motivation. Student motivation, according to Bomia et al (1997: 1) "refers to a student's willingness, need, desire and compulsion to participate in, and be successful in, the learning process." As far back as 1955, Hebb formulated the concept of 'optimal hedonic tone'. This concept postulates that performance in learning is achieved at a moderate level of arousal. Too little arousal leads to boredom, and too much arousal leads to anxiety, both of which inhibit effective performance. It is important therefore to achieve the optimal hedonic tone in teaching. An ideal teaching system will allow each student to work at his or her own pace and allow the facilitator to regulate the levels of boredom and anxiety optimally for each student.

Students' motivation has often been presented in two categories by various authors such as Brewster and Fager (2000), Middleton & Spanias (1999) and Dev (1997), as follows:

- *Extrinsic motivation*: A student can be described as extrinsically motivated when he or she engages in learning "purely for the sake of attaining a reward or for avoiding some punishment" (Dev as cited in Brewster and Fager 2000). Brooks et al (as cited in Brewster and Fager 2000) describe school practices

that attempt to motivate students extrinsically by providing public recognition of students' academic achievements; giving out rewards such as stickers and sweets; and taking away privileges, such as school breaks, on the basis of students' academic performance.

- *Intrinsic motivation*: According to Brewster and Fager (ibid: 3) "A student can be described as intrinsically motivated when he or she is motivated from within. Intrinsically motivated students actively engage themselves in learning out of curiosity, interest, or enjoyment, or in order to achieve their own intellectual and personal goals." This view is supported by Dev (as cited in Brewster and Fager 2000) who defines an intrinsically motivated student as one who does not need "any type of reward or incentive to initiate or complete a task. This type of student is more likely to complete the chosen task and be excited by the challenging nature of an activity."

Both categories of motivation lead to learning and are therefore important. Often a student begins a section of work in an extrinsically motivated way. The subject material becomes interesting and his/her curiosity draws the student to become intrinsically motivated. This means that a student may shift from being extrinsically to being intrinsically motivated. A good teaching system must assist motivation by, for example, providing achievable goals and adequate feedback when these goals are reached.

### **2.2.3 Surface and deep approaches to learning**

Once the student is motivated to learn, he/she will adopt an approach to the learning task at hand. There are a number of approaches to learning that have been identified through research (Marton and Säljö 1976; Entwistle 1981; Nightingale et al. 1996), the main ones being the surface approach, the deep approach and the strategic approach.

### **2.2.4 Surface approach to learning**

In the surface approach to learning, the task has an extrinsic value, for example, the grade achieved or simply getting the task done. Nightingale (1996:267) states that the surface approach to learning is:

Where a student is motivated extrinsically to focus on selected details of content; and to study so as to reproduce these details accurately, attending to separate bits, elements or components of what they study rather than the overall picture. Learning is seen as a matter of how much is learned; and teaching is conceived as a process of transmitting knowledge.

### **2.2.5 Deep approach to learning**

According to Nightingale (1996:267) the deep approach to learning is:

Where a student is motivated intrinsically to satisfy curiosity about a topic. To maximize understanding, the student reads widely, discusses issues and reflects on what has been heard and read, integrating details into broad, over-arching ideas which she or he is constantly trying to develop. Learning is seen as involving meaning, understanding, and a way of interpreting the world. It is the learner who constructs knowledge, not the teacher who imparts it.

In the deep approach to learning the task has an intrinsic value such as the satisfaction of understanding the concept and being able to see its position in the learner's greater understanding of meaning and relation to everyday experience.

### **2.2.6 Approaches or categories**

It is important to note that these are *approaches* to studying. They are *not* categories in which to place students. "These approaches are analytic categories derived from research and thus only describe the relative prominence of each approach to studying in a student (Entwistle, McCune and Walker 2000: 49)."

Furthermore Atherton (2003) makes the point that there is a correlation between "deep approach" and "intrinsic motivation", and between "surface approach" and "extrinsic motivation", but they are not necessarily the same thing. He points out that either approach can be adopted by a person with either motivation.

These approaches should also be considered from the standpoint of the educator. The educator may adopt a deep or surface approach. The educator may aim to just cover the work, or get it done. The educator may expect a surface performance from the students and assess accordingly. Thus, students who may be intrinsically motivated would diligently learn in the surface approach offered on the course. In other words, there may be students with deep and surface approaches to the subject material, but they will be receiving a

surface treatment of the material from the educator. Similarly educators may take a deep approach with students who have a surface approach.

### **2.2.7 Strategic approach to studying**

The “strategic approach” is given as an additional approach to studying (Entwistle and Ramsden, 1983). This term describes students with an intention to achieve the highest grade possible through effective time management and organised study methods and an alertness to the assessment process. Such an approach does not necessarily entail deep learning, but is effective for short term memory tasks of atomistic assessment.

It is important in the development of any course material to be aware of learning approaches, and to teach and assess with the intention of engendering deep learning. In particular, where learning material tends towards atomistic questions that test the lower categories of Bloom’s taxonomy such as remembering, understanding and applying, it is important that the material is strongly articulated. It must be clear to the student how all the little bits join up to form the big picture and how a missing little bit will cause the big picture to fail.

### **2.2.8 How to uncover a student’s approach**

It is important to note that, although the definition of surface learning has observable behaviours, it is more appropriate to ask the student how he or she feels about the learning taking place. This is confirmed by the research carried out by Säljö (1979b and 1979c) investigating “conceptions of learning”. They asked their students what *they* thought learning was (Säljö 1979a). In the present study students’ views were sought through semi-structured interviews of the experimental group of students.

### **2.2.9 Ideographic or nomothetic approach to learning**

Approaches to learning may also differ depending on the vantage point from which they are viewed. The word “nomothetic” refers to rules or laws that pertain to the general case and is derived from the Greek word “nomos”. The word “ideographic” refers to rules or laws that pertain to individuals and also has Greek origins. In the context of learning this

means that an idiographic approach to learning is that it is seen from a student's point of view (Trochim 2002). In the case of the proposed mastery system, it is idiographic from the students' point of view because they work at their own pace, they measure performance against themselves and the questions are also idiographic in that they are randomly generated by the computer.

Learning is nomothetic if it is approached from the educator's point of view and presented in general to all students. From the educator's point of view the proposed mastery system is nomothetic in that the scores achieved and time taken are looked at from a general vantage.

### **2.2.10 Bloom's taxonomy and approaches to learning**

Bloom's taxonomy describes levels of cognition or levels of learning. The concepts of deep and surface learning describe approaches to learning. There is a connection between the taxonomy and the concept of deep and surface learning: the lower orders of Bloom's taxonomy appear to relate to surface learning such as simply remembering facts without being able to apply them; and the higher orders appear to relate to deep learning, such as evaluating facts and creating new ideas. The original material used to form these categories appears to be text and prose as the categories in Bloom's taxonomy are often illustrated with literature or history as subject material. However Bloom (1974) did projects in mathematics learning and some investigators such as Mevarech (1988), have tried to apply the taxonomy to mathematics learning.

### **2.2.11 Learning approaches and mathematics**

The author has used Bloom's levels of cognition as categories for analysing the learning of mathematics but they sometimes caused difficulty as the following example illustrates. The correct answer to a mathematics problem does not necessarily indicate what approach the student used. The same and correct answer will not reveal a deep or surface approach and could indicate the lowest or highest orders of cognition. For example Question 14a of the post-test, used in this study, (Appendix I) asks the student to calculate the area of a "122 ° pie slice" of a circle.

There are three possible learner reactions:



1. *Daunted*. The student feels this problem is too difficult, the shape of the area to be calculated looks very odd and the student will step back and give up.
2. *Remembering and applying*. The student *remembers* that he has been shown that the area of a quarter circle, a semi-circle or any other fraction of a circle is simply the fraction multiplied by the area of the whole circle. (In this case  $122^\circ / 360^\circ \pi \times 4 \times 4$ ) and solves the problem by remembering and applying.
3. *Analysing and creating*. The student has never seen this kind of problem before. He analyses the problem logically: two half circles make a whole, four quarters make a whole and, therefore, that 360 times one degree pie slices make a whole. This leads him to creating a formula and arriving at the correct answer by multiplying one slice by 122. The student has solved the problem by analysing and creating.

The dilemma is that although the answer is the same in the second and third approach the levels of cognition are completely different. An observer cannot tell which approach the student has used. In the second approach the student has used *remembering and applying*. In the third approach the student has *analysed* the problem, worked on the half, quarter and  $360^{\text{th}}$  of a circle, *evaluated* the results and then *created* a new and unique solution. He has used the highest orders of cognition and arrived at the same result.

This dilemma has often become apparent when trying to categorise mathematical testing. The author has concluded that the correct answer is not an indicator of the approach adopted by the student, unless one can be sure that the type of problem has never been used before. The most accurate way of knowing the student's approach is by asking the student, which is what Marton (1978) described as a "second-order" or "from-the-inside" perspective.

### 2.3 Language issues

South Africa has eleven official languages. Tertiary instruction is delivered primarily in English. The majority of students use English as a second or third language. The non-

English speaking students' difficulties are further exacerbated by cultural differences and often a "disadvantaged" education as mentioned in Chapter 1.

### **2.3.1 Vocabulary, mathematics and quantity surveying**

Pretorius and Bohlman (2003) consider the relationship between poorly developed reading skills and academic performance in mathematics. South Africans perform very poorly at mathematics when compared to the rest of the world and even when compared to other African countries. According to Pretorius and Bohlman (ibid), poor mathematical performance is linked to poor language skills. They posit that in language use, there is a high frequency vocabulary of 5000 to 6000 words. Thus in the case of the students involved in this study, it is expected that they would have such a low frequency vocabulary in maths. These are the words which we use frequently every day. In our specific career or trade we should each have a low frequency vocabulary of 800 to 1000 words. If this low frequency vocabulary is poorly developed, the learning of mathematics, for example, could be severely hindered. This could be a contributing factor to the poor performance of many students.

By extrapolating Pretorius and Bohlman's (ibid) conclusions, it could be argued that poor vocabulary inhibits almost all areas of study. The intervention must therefore address competency in career specific vocabulary and it must also be sensitive in distinguishing between maths inability and language handicap, as mentioned in the introduction. Chapter 3 will expand on this theme.

Prins and Ulijn (1998) go beyond the limitations of vocabulary and consider how cultural differences, as well as the readability of text, can affect a student. The study sampled over 300 students aged 17 to 18 years at twelve rural and suburban schools, in South Africa. In the presentation of mathematics problems, they reduced the amount of context that is culturally unfamiliar to students, and they improved the readability of the texts. The experiments revealed that the non-English speaking students achieved better results. They concluded that:

Although writers cannot be held responsible for the language and mathematics proficiency of students, they do have the responsibility to consider their reading audience with care and write accordingly. (ibid: 157)

## 2.4 Formative assessment

Formative assessment is closely linked to motivation in that it provides feedback on performance. The Education, Training and Development Quality Assurance (ETDQA) defines the concept as follows:

Formative assessment is assessment designed to support and inform educators and learners so as to ensure continuing progress towards the outcomes, unit standards and skills programmes or qualifications targeted. (2003: 25)

This is supported by Nightingale (1996: 269) who gives this definition:

Formative assessment is used to give students feedback on their progress towards achieving the intended student learning outcomes in a subject or unit. Used to refer to any assessment whether graded or ungraded, which has as its primary purpose the encouragement of student learning by the provision of feedback on performance.

Almost all students want to pass and do well in their studies and are therefore keenly interested in how they are doing. Formative assessment with feedback will help them know how they are doing. Rowntree (1977: 24) explains that:

Effective feedback enables the student to identify his strengths and weaknesses and shows him how to improve where weak or build upon what he does best.

He goes on to emphasise how important feedback is to learning by noting: “Feedback, or knowledge of results, is the lifeblood of learning”(ibid: 24). Strong et al. (1995) argue that feedback that is provided soon after the assessment has taken place is more effective than late feedback. One of the strengths of an electronic mastery system is that feedback is rapid. Rowntree (1977: 26) cited Robert Birney (1964) who “found that college students were agreeable to frequent assessment – so long as it was ‘in language they understand’ . That is, not in grades or marks, which told them nothing specific about their strengths and weaknesses, but in detailed verbal commentary.” It is therefore important that a teaching system should assess the student’s progress regularly and provide feedback that is prompt and meaningful.

## 2.5 Mastery learning

This section will describe conventional classroom teaching and learning. Then it will go on to discuss mastery learning with the view to comparing the two systems.

### 2.5.1 Conventional classroom teaching

Gusky (1988), basing his argument on Bloom's investigations of group-based classes, suggests that the educator generally divides the year's curriculum content up into a number of units, and he or she will, for each unit:

- give instruction of one unit
- give a test (summative assessment)
- the results of the test will be recorded as final results for that unit
- s/he will regard the unit as completed, that no more time will be spent on that unit, and that the results are final
- s/he will then begin with the next unit (adapted from Guskey 1988: 3626).

The results usually show a normal distribution (bell curve) where some students will do very well, the majority will do moderately well, and some students will do poorly.

Eisner (2000) also makes the point that there was a long-held assumption that there would always be a normal distribution of results.

Figure 1 illustrates the conventional classroom teaching model diagrammatically.

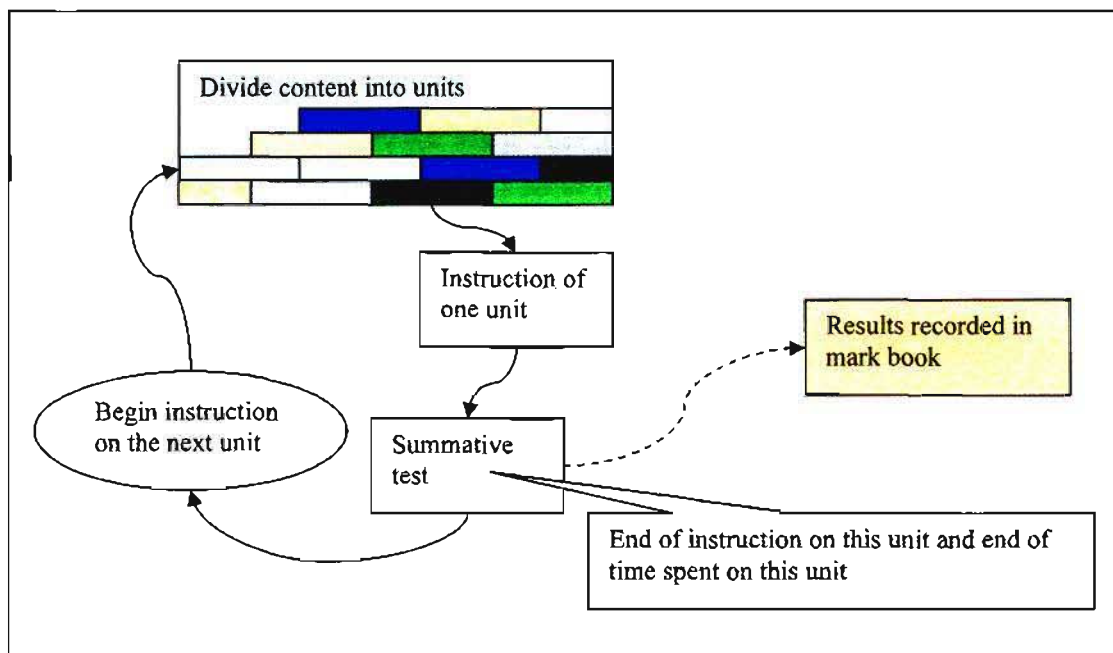


Figure 1: Conventional teaching model (adapted from Guskey 1988: 3626)

Guskey's conventional teaching model does not include revision or formative assessments, which do often take place in secondary and tertiary education.

### 2.5.2 Mastery learning-background

Mastery learning concepts have been documented since the early 1900s by, for example, Washburne (1922) and Morrison (1926). Bloom (1974) credits pioneers such as Comenius, Pestalozzi and Herbart. However, Guskey (1988) attributes the modern interest and application of mastery learning to the writings and research of Bloom. Guskey (1988: 3625) notes that

few strategies have been implemented as broadly or evaluated as thoroughly ... students in mastery learning classes consistently learn better, reach higher levels of achievement, and develop greater confidence in their ability to learn and in themselves as learners.

In contrast to the then currently held understanding regarding the normal distribution of results, Bloom, observed that “while students learn at different rates, virtually all learn well when provided with the necessary time and appropriate learning conditions” (as cited in Guskey 1988: 3626).

Bloom developed his model, originally called “learning for mastery”, from observing two sources of information. The first source of information Bloom drew from was the ideal learning situation between an excellent tutor and an individual student. He observed what critical elements in one-to-one teaching could be transferred to group-based settings. As a second source of information, Bloom drew from the learning strategies of successful students. His mastery learning model was then formulated as follows:

- give instruction (similar to the traditional model)
- give a test (formative assessment)
- take careful note of the results and use the results to:
  - diagnose individual learning difficulties
  - provide individual feedback
  - prescribe specific remediation.
- Give explicit suggestions on how to correct the learning difficulties identified. The remediation must be individualised. The student is only required to work on the concepts not yet mastered.
- Administer a second or subsequent test. This test has two important components:

### 2.5.3 Essential elements of mastery

In 1987, following on Blooms' work, Guskey (1988: 3627) clarified two elements as essential to the implementation of mastery learning:

#### 1. Feedback, correctives and enrichment

- Feedback must:
  - Reinforce what is most important
  - Recognise what is learned well
  - Identify what needs remediation
- Correctives – explicit guidance and direction on how to correct their learning
  - The corrective must be different from the original instruction
  - The correctives should incorporate different learning styles of learning modalities
- Enrichment or extension should be provided for students who attain mastery after the initial teaching.

#### 2. Congruence among instructional components

The instruction and the assessment must be pitched at the same skills. If the instruction teaches knowledge but the assessment assesses application then it is incongruent.

### 2.5.4 Mastery learning and time

What is implicit in the above model is that each student may work at his or her own pace.

Eisner (2000: 4) explained Bloom's view, that

it made no pedagogical sense to expect all students to take the same amount of time to achieve the same objectives. There were individual differences among students, and the important thing was to accommodate those differences in order to promote learning rather than to hold time constant and to expect some students to fail. Education was not a race.

While allowing each student to work at his or her own pace, it remains important that the mastery system provides sufficient pressure to prevent the student from becoming bored.

### 2.5.5 Optimal level of challenge

Ryan and Connell (1990: 286) emphasise the importance of an optimal level of challenge to keep students motivated:

Mastery learning leads to increased student motivation. Students provided with tasks and problems just above their level of competence are likely to show enhanced interest and persistence, however when students are challenged either below or above optimal levels of challenge they show either boredom and disinterest or anxiety and lack of interest.

This concurs with Hebb's (1955) concept of optimal hedonic tone discussed earlier in this chapter.

In the development of a mastery system, it is important to ensure that students do have sufficient time and correct conditions to master each topic and that the student is optimally challenged.

### 2.5.6 Characteristics of mastery learning

Guskey (1988) has summarised the research results of various studies regarding mastery learning and points to the following characteristics, which are paraphrased below:

- *It is flexible in its application:* there is no single best way to implement a mastery learning programme.
- *It is broadly applicable:* it can be used for subjects that are structured and hierarchical such as mathematics, but it can also be used for subjects that are not necessarily structured such as language, art and social studies. Mastery learning can be appropriately applied to any level of Bloom's Taxonomy, i.e. knowledge, comprehension, application, analysis, synthesis or evaluation.
- *It builds upon existing techniques:* most educators do not need to make drastic changes to their existing teaching techniques. They may, for example, just need to give attention to the feedback and remediation parts of the teaching cycle.
- *It delivers positive effects:* using a mastery strategy leads to significant improvements in student learning.

- *It has multidimensional impact:* a mastery programme causes other positive side effects such as improved attendance, greater participation in class lessons and a better attitude towards learning.

(Adapted from Guskey, 1988)

### 2.5.7 Mastery in mathematics

Joyce and Weil (1980) express their doubt that mastery learning is as easy to implement as some of mastery learning's proponents, such as Bloom (1968) and Block and Burns (1976), say it is. As an example of a mastery system Joyce and Weil (ibid) cite the Individually Prescribed Instruction (IPI) programme developed by the Learning Research and Development Centre at the University of Pittsburgh. This is a very comprehensive system that covers five curriculum areas: mathematics, reading, science, handwriting and spelling. More specifically in mathematics, the program has thirteen topics, over four hundred specific behavioural objectives and each topic is divided into nine levels of difficulty.

Despite the comprehensive learning material, the application of the programme is labour intensive. Each student works at his or her own pace and has to be given the correct study material for each stage. Students that have learning problems in a particular area need to be grouped with others with the same problems and given personal tuition. The students have to be evaluated individually. If they have mastered the unit, they can proceed to the next level; if not, then they have to be put through a remedial loop. Each of these aspects is time-consuming for the teacher.

Joyce and Weil (ibid) explain that the complications do not end there, as the IPI programme acknowledges that students learn by different approaches. For example:

- some students may need more practice in the use of a concept,
- others learn a concept more effectively by being given examples in which they must decide what is and what is not an instance of the concept, and
- still others have difficulty transferring behaviour from one situation to another and need experience with a variety of formats for using the concept.

The IPI system was not computerised. It made use of worksheets and answer sheets. A sophisticated computerised system could streamline part of this process, but it would still



require a highly-skilled teacher to direct and motivate the class and intervene when pupils have difficulty with a section.

### **2.5.8 Mastery in mathematics – computation or comprehension**

Mevarech (1985) carried out research that compared four groups of Israeli school children. The children were taught fractions using various learning methods. The first group used mastery learning strategies (MLS), the second used student team learning (STL) techniques, the third used a combined learning strategy termed student team mastery learning (STML) and the fourth was a control group.

The purpose of the research was to:

- discern the relative effects of cooperative learning and mastery learning in the context of computation and comprehension of mathematical problems.
- report on the different effects that the strategies had on low, medium and high achieving students.

The mastery groups (MLS and STML) had the benefit of a formative assessment, followed by feedback, and then, either corrective or enrichment activities. The other two groups did not have these benefits. The cooperative learning groups (STL and STML) also had the benefit of group interaction.

The conclusions drawn from this research are that

- the two groups that had a mastery component (MLS and STML) did significantly better than the two groups that did not.
- the mastery by teams interaction (STML) produced significant effects on computation-type problems but not on comprehension-type problems.

A core principle of mastery systems is that time should not be held constant (Eisner, 2000). This means allowing each individual enough time to master the material at his or her own pace. In Mavarech's study, no extra time was afforded to the mastery groups, but despite this deviation from mastery principles, the author reports that the mastery groups did significantly better than the other groups. It could be concluded that the scores may have been higher had more time been allowed.

In their revision of Bloom's taxonomy of educational objectives, Andersen and Krathwohl (2001) state that a mathematical computation falls into the third level of cognition, which is *applying*, and comprehension of a mathematical word problem falls into the fourth level of cognition, which is *analyzing*.

Mavarech did further analysis of the data by separating the results of low, medium and high achievers and separating scores achieved in mathematical problems that only required computation and those that required comprehension followed by computation. The results showed that:

- in computation, the mastery group (MLS) did best for low, medium and high achievers.
- in comprehension and computation, the low achievers in the co-operative groups (STL and STML) did better than the mastery group (MLS). The medium and high achievers performed best in the mastery group (MLS).

It could be deduced that the low achievers found it helpful to discuss a comprehension problem in a group in order to understand it better.

According to Doyle (1983), instructional methods that are appropriate for increasing computational proficiency are not necessarily suitable for developing mathematical comprehension. Mavarech's research seems to confirm this in the case of low achievers.

This Israeli study is instructive because it shows that mastery learning out-performed other study methods in most cases; however, blending mastery learning with team learning techniques may have further advantages.

### **2.5.9 Motivation and achievement in mathematics**

In another study, Mavarech (1988) researched the motivation of children learning mathematics in a computer aided instruction (CAI) environment. The study categorised the subjects according to cognitive achievement levels in mastery and motivational orientation.

Mavarech (*ibid*) stated that intrinsically motivated children have a tendency to figure out problems on their own and would benefit from activities that support these types of

activities. Extrinsically motivated children perform better in situations where teachers' help is available and where more feedback is available.

According to this model, intrinsically motivated children, because of their tendency to attain mastery and figure out problems on their own, would benefit in schools that strongly support these types of activities. Extrinsically motivated children, on the other hand, are known to prefer easier assignments and to rely on external guidance, and thus they would perform better in situations where the teachers help is available. (Mevarech 1988:228)

Mevarech claimed that the results showed that instructional efficiency of CAI is related to pupils' intrinsic orientation.

He noted that "many children indicated that they did not know whether they had mastered a task without being provided with external feedback" (1988: 231). This comment indicates the importance of the type of feedback that can be given through mastery learning.

A proposed mastery learning system for quantity surveying students should take into account the different motivational orientations that students may have. It should, for example, provide sufficient material for intrinsically motivated students to use on their own as well as sufficient feedback to satisfy the needs of extrinsically motivated students.

### **2.5.10 Mastery learning reconsidered**

However, not all reports on mastery learning are positive. In a report on mastery learning systems, Slavin (1987:175) found

*essentially no evidence to support the effectiveness of group-based mastery learning on standardised achievement measures. On experimenter-made measures, effects were generally positive but moderate in magnitude, with little evidence that effects maintained over time.*

However, Slavin's report was inspected and found to have used

*techniques of questionable validity, employed capricious selection criteria, reported results in a biased manner and drew conclusions not substantiated by the evidence presented. (Guskey 1988:3630)*

### **2.5.11 Excellence through mastery learning**

"Mastery strategies may not work quite as well as their advocates propose, but they do work very well indeed" (Block 1985:269). Block and Burns stated that provided the

preconditions and operating procedures are met, their research of over forty rigorous studies posits that mastery learning has the following advantages:

*Learning effectiveness.* Mastery-taught students typically learned more effectively than their non-mastery-taught counterparts. Whether learning was measured in terms of student achievement or in terms of student retention, they almost always learned more, and usually significantly more, and they learned more like one another.

*Learning efficiency.* Mastery-taught students also typically learned more efficiently than their non-mastery-taught counterparts. ...

*Learner affect.* Lastly, mastery-taught students liked their learning, their teaching and themselves better than their non-mastery-taught counterparts. (as cited in Block 1985: 269)

## **2.6 Key competencies**

As mentioned in the previous chapter, student competency in mathematics in the South African education system is weak. (Refer to Chapter 1: Departmental Context.) School leavers registering for the National Diploma: Building would have passed mathematics at grade 12 level in order to register.

The Exit Level Outcomes for mathematics as established by the South African Qualifications Authority (SAQA) are as follows:

- 2.1. Recognise, describe, represent and work with numbers and their relationships to estimate, calculate and check in solving problems.
- 2.2. Investigate, analyse, describe and represent a wide range of functions and solve related problems.
- 2.3. Describe, represent, analyse and explain properties of shapes in 2- and 3-dimensional space with justification.
- 2.4. Collect and use data to establish statistical and probability models to solve related problems. (South African Qualifications Authority, n.d.)

These outcomes are regarded as key competencies in that they are essential to be able to progress successfully in the National Diploma: Building course.

### **2.6.1 Atomistic versus holistic approach**

Competence can be approached holistically or atomistically. The competencies contemplated in this study are atomistic in nature which means that the competencies are measured initially as elementary units. For example mental arithmetic involves the four basic operations – addition, multiplication, subtraction and division – that can be achieved

without a calculator. Mathematics involves the calculation of areas, lengths and volumes. The assessment of competence in these areas can be done with short questions and answers.

### **Holistic approach**

Some of the literature on competency testing, for example, “General Issues about Assessment of Competence” (Hager et al, 1994), is based on holistic workplace observation of knowledge, skills and values in work-based processes such as in a doctor’s surgery. Twenty-one professions in Australia have adopted an “integrated conception of competence” where “competence is conceptualized in terms of knowledge, abilities, skills and attitudes displayed in the context of a carefully chosen set of realistic professional tasks” (Hager et al, 1994). This type of testing is to assess if a student has the competence to be a practitioner in the profession.

### **Atomistic approach**

In contrast this study focuses on competencies that a student in quantity surveying should have in order to begin and complete his course successfully. Towards the end of the student’s tertiary education, he or she should also be assessed for holistic professional competence as described above.

## **2.7 Implementation of mastery concepts**

The first part of Chapter 2 explains the literature background to learning and to mastery learning in particular. This section draws on the literature to describe theoretically what a mastery system designed for quantity surveying students should encompass.

It should:

- be progressive – begin with remembering, then proceed to understanding, then application and, where possible, analyse, evaluate and create (Bloom 1956)
- separate computation, vocabulary and comprehension (Mevarech 1988)
- engender intrinsic motivation (Dev 1997)
- engender deep learning (Nightingale 1996)

While having the qualities above, the mastery system should also uphold the mastery principles as described by Guskey (1988). It should:

- be in manageable sized units

- give instruction
- use diagnostic tests
- provide feedback
- provide individualised remediation *or* enrichment
- have further formative tests

The scope of the mastery system is the achievement of the key competencies that junior quantity surveying students should have as a minimum basis for their careers, broadly categorised as:

- mental arithmetic
- mathematics
- drawing interpretation
- measuring
- vocabulary

The above forms a multidimensional matrix of the qualities, principles and scope that a mastery system should have. Some of the items listed above will be illustrated individually, but there is an overlap where one question will test more than one quality. A question may test application and comprehension. Another question may be designed to test *creation* but might test *remembering* as well, depending on the student concerned. The source of a student's motivation is more than one subject and is difficult to measure but the system must at least take cognisance of the concept of motivation. Illustrations of some of the above qualities in the form of test examples follow:

### **2.7.1 Levels of learning should be progressive**

To illustrate these principles, mathematics examples have been used:

#### **Example 1: Remember - Recognise**

Consider the following questions:

**Names of the attributes of a circle:**

1. By colouring in or annotating, label the following:
  - a) Radius
  - b) Diameter
  - c) Area
  - d) Circumference
  - e) Centre

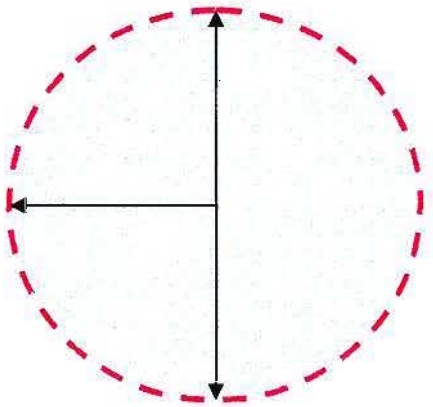


Figure 3: Recognise

This question tests *knowledge*. This is the lowest level of cognition of Blooms taxonomy. The student has to simply learn and *recognise* the attributes of a circle. (Notice that this level does not require the student to *understand* what these attributes mean or *apply* them in any way.) Although this appears extremely simple, because learning is progressive, as explained in Chapter 2, this first step must be in place and mastered before a student can progress successfully to the next level of cognition.

#### **Example 2: Remember - Recall**

The following question tests *recall*:

**Names of the attributes of a circle:**  
Draw a diagram of a circle, illustrate and name five attributes.

Figure 4: Remember - Recall

Still within the *remember* domain this question is slightly more difficult in that the student needs to *recall* the knowledge that he or she has learned.

Recognising and recalling do not imply understanding.

### Example 3: Understanding

This question tests *understanding* of the knowledge that the student has *remembered*.

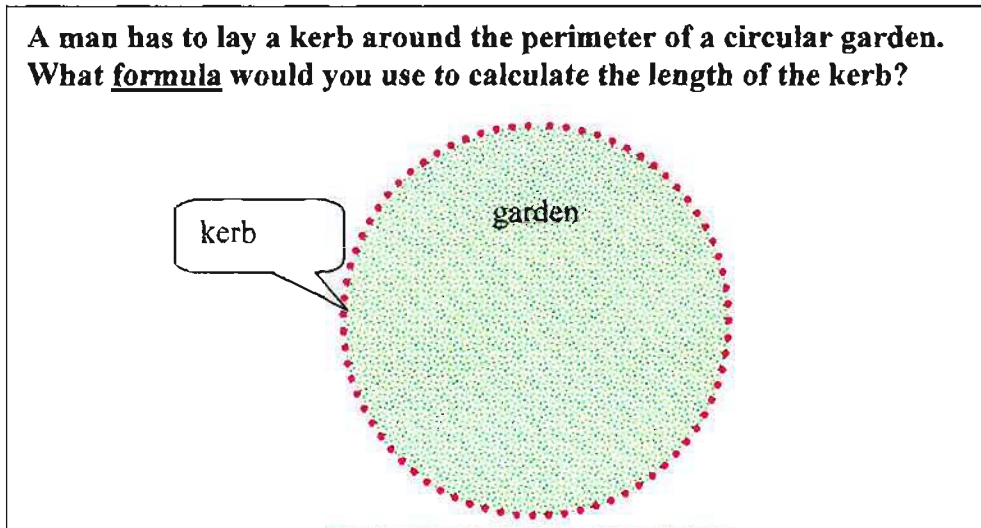


Figure 5: Understanding

The answer is:  $\text{Perimeter} = \pi \times \text{Diameter}$ . Answering this question correctly shows that although the student may have learned at least two formulae for circles, he or she *understands* their purpose by answering with the correct one. (This question is not testing vocabulary – in case the student is not familiar with the word “kerb”, for instance, it is illustrated.)

### Example 4: Application

This example question tests *application*.



Calculate the following:

1. Diameter
2. Circumference
3. Area

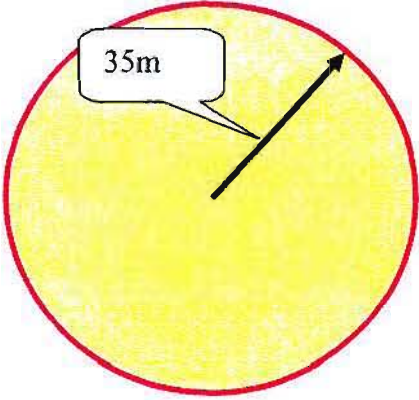


Figure 6: Application

The above question demonstrates that the student can *recall* the formulae, *understand* how to use them and *apply* the formula to the question to produce the answers.

The above four examples show that mathematics questions can be authored to be progressive.

### 2.7.2 Separate computation, vocabulary, comprehension

Without mathematical vocabulary, a student cannot progress in mathematics as shown by Pretorius and Bohlman (2003) and explained earlier in this chapter. The following two examples illustrate how mastery questions can be structured to test computation, vocabulary and comprehension. In this study **vocabulary** as a key competency includes a basic working vocabulary in English and a “low frequency” vocabulary of construction-specific words such as kerb, pillar, column, and mathematics-specific words such as radius or circumference. This skill fits into the *remember* category of Andersen and Krathwohl’s (2001) taxonomy. Examples 1 and 2 test mathematics specific vocabulary.

Comprehension is the ability to understand written learning material and understand mastery questions that are not supported by diagrams. This entails the decoding of sentences. This skill fits into the *understand* category of Bloom’s taxonomy.

Comprehension is best tested where it involves a computation. Observation of the answer

will not reveal where a student has difficulty. A correct answer will indicate that the student has got both the comprehension *and* the computation correct. An incorrect answer means that the student has either not comprehended *or* not calculated correctly *or* both. However, diagnosis of the students' calculations would reveal a comprehension problem and/or a computation problem.

**Example 5: A question that only tests computation**

The following question does not test comprehension:

A circle has a radius of 25 metres.  
What is its perimeter?

Figure 7: A question that only tests computation

To answer this question students have to know the mathematics-specific vocabulary such as radius and perimeter and be able to *apply* the formula they have *remembered*.

**Example 6 Comprehension and computation**

The following question tests comprehension and computation.

A circular garden has a radius of 25 metres.  
How many metres does a man have to walk to go around the outside edge of the garden?

Figure 8: Comprehension and computation

The student has to *comprehend* the question and then *apply* knowledge and understanding gained at previous levels of learning to solve this problem.

Comprehension: The choice of the wording “to go around the *outside edge* of the garden” as opposed to the more direct wording of “to go around the *circumference* of the garden” is

deliberate. This will show that a student who has memorised “the circumference of a circle is  $\pi \times$  diameter” (or the circumference of a circle is  $\pi \times$  radius ) will have to know that the circumference means the outside edge of the circle.

Calculation: The calculation of the answer has to be done by applying either formula and calculating the answer. By getting the correct answer, the student has demonstrated that he or she has comprehended the question, applied the correct knowledge and computed the correct answer.

A mastery system should test computation, and computation and comprehension as shown in examples 5 and 6 above. Further, in the case of a question that tests computation and comprehension together such as example 6, the mastery system should, as far as possible, be able to distinguish if the student got the comprehension part or the computation part right or wrong.

### 2.7.3 Engender intrinsic motivation

As explained in Chapter 2, there are several factors that stimulate intrinsic motivation. The design of a mastery system should consider the following:

- a) **Optimal hedonic tone.** Students work best under an “optimal hedonic tone” where students are neither bored nor anxious. Mastery learning allows each student to work at his or her own pace. This will alleviate boredom or anxiety to some extent. Extension exercises should alleviate boredom in the students who find the work easy.
- b) **Feedback.** The system should give the student meaningful feedback and do so rapidly.
- c) **Personal control.** The student should be in control of his or her learning, and feel that it is possible to master the work and enjoy the results of his or her progress.
- d) **Support.** The student must also feel supported, welcome, and enjoy verbal praise and encouragement. The facilitator of an electronic system must provide this support personally. This can be done by being physically present or by email, discussion forum and chat room facilities.

#### **2.7.4 Engender deep learning**

As mentioned in Chapter 2, a student's approach to learning can be said to be deep or surface. Further, learning material can either support or discourage a surface approach. Assessment can reward or discourage a mode of learning too.

#### **Strategies that will encourage deep learning:**

##### Progressive approach

The progressive approach to learning described in the beginning of this chapter is essential to guard against surface learning. The student will have to pass through progressive stages from knowledge to comprehension to application. A surface learner will want to jump to the level of application without having the necessary grounding in the relevant vocabulary and understanding of what he or she is doing. For example, if a student could recite and use a formula to calculate the area of a circle but did not know what the concept of area really means he or she would only have a "surface" understanding of the concept.

The surface learner may score correct answers for a while, but at some stage will fail in areas where a two or three-step approach is required

##### Retention

Surface learners tend to forget what they have learned. By re-testing key concepts often, deep learning is encouraged.

##### Relevance and interconnectedness

Surface learners can alter their approach when they realise that the material is interconnected and every piece of knowledge remembered enables and empowers further learning. The material should reflect connection with earlier material.

##### Inverse questions

An inverse question is a very good way of testing depth.

For example, if the conventional examples and exercises followed the format of "choose the correct formula, apply the variables and compute the answer", an inverse question

would read: “Here is an answer – how was it calculated and what are the values of the variables?”

#### Example 7: An inverse question

The formula that students are most familiar with for area of a circle is  $\pi \times R \times R$  (radius being the variable). In Figure 9, the area is given and the radius is the unknown variable that the student is required to calculate.

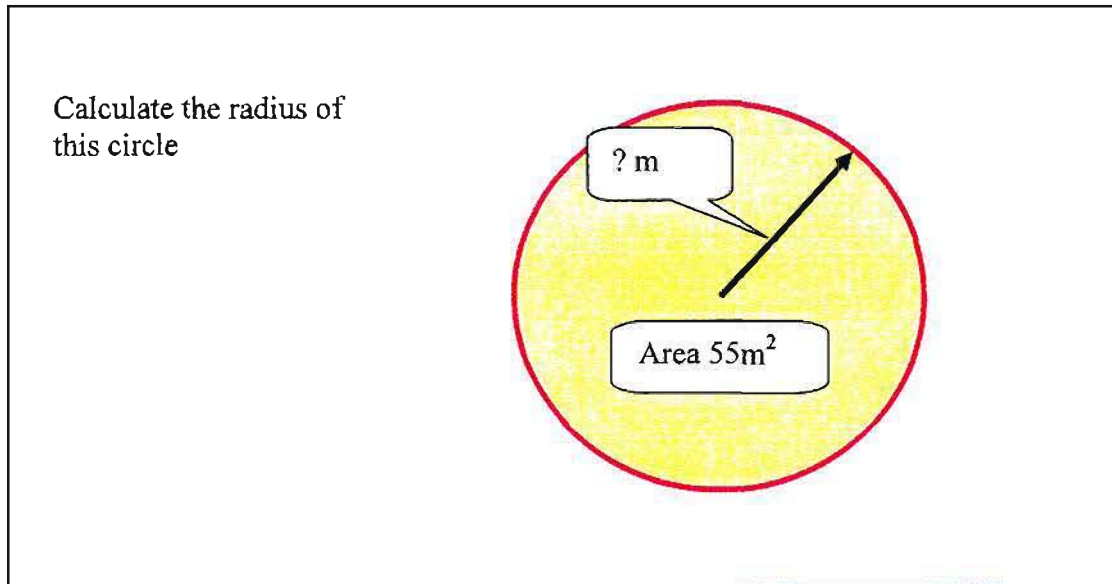


Figure 9: An inverse question

The insight and mathematical agility that is required to answer this type of question will indicate deep learning.

## **2.8 Examples of a mastery learning system and an e-based learning system**

This section gives an example of an existing paper-based mastery learning system which shows the practical application of mastery learning principles. To illustrate the possible complexities of applying such a system, a medical school’s report on “electrifying” a course is also cited.

### **2.8.1 Applying maths in construction**

A comprehensive publication called ‘Applying Maths in Construction’ (Tourret and Humphreys 1997) is a detailed pack of paper-based learning material which develops a

student's number skills and study skills. It consists of thirty modules and is written for students on vocational courses in construction.

Each module begins with a short assessment. The student then marks his or her own work, guided by answer sheets. The answer sheets to the assessments guide the student to the appropriate study material. If a student gets a section correct he or she has the *option* to study the relevant material; however, a student who gets a section wrong *must* work through the relevant section carefully. There are approximately five sections in each module. Each section provides instruction content, followed by an assessment that the student marks him/herself from answers given at the end of the module. On completion of all the sections in a module, the student does a final review test which will confirm that the student has mastered the module. The answers to the review test are contained in a separate publication. This test may be marked by the student or by the course facilitator. The students are advised to ask for help for any items, in the review test, that they have not got correct.

'Applying Maths in Construction' follows Bloom's mastery learning model (Guskey 1988) closely in that it provides formative assessment, diagnoses and provides remedial study material. The student is not obliged to do sections that he or she is competent in; they can work at their own pace, and undertake the review test as conclusive proof of mastery before moving on to the next module. Considering the self-directed and flexible nature of this mastery learning package, it would be quite easily transferred to an e-based learning system. However, other considerations may have to be taken into account, as illustrated by the application of an e-based learning programme in a medical school, described by Hoban et al (2003).

### **2.8.2 E-Based learning**

E-mastery learning implies an optimal level of computer literacy and access to computer facilities for students, while for educators it requires flexibility and commitment. As Heap et al (2004:248) pointed out in their study of how ICT-based assessment can support best practice for engineering students:

For students the key issue is gaining confidence in the use of the technology. For teachers the issues relate to changing work loads, quality assurance and careful evaluation of systems.

Hoban et al (2003:145) explained that the conversion of existing course material was “hard work and time consuming”. They found that the students were resistant to using computers for course work. They explained that it was due to lower than expected levels of computer literacy. However, they reasoned that as medical educators they were obliged to prepare students for medical practice and that this included practical levels of computer literacy. The issues raised here are similar to those encountered by the author during the experiment described in this study where students also found computer literacy a problem in accessing e-based learning material and as graduate quantity surveyors they should be computer literate. The students’ computer literacy problems are discussed further in the Data Analysis Chapter.

## 2.9 Summary

This chapter has reviewed literature in the context of how it can be applied in the construction and assessment of mastery learning systems that build competency in key areas for quantity surveying students.

A mastery learning system must be structured in a progressive order where a student masters the different levels of cognition in a progressive way, for example, *remembering*, then *understanding* and thereafter *applying*. Each student must be allowed to progress at a unique pace. The system must be flexible enough to cater for each student’s pace so that s/he does not become bored or daunted. For it to be successful, the system must contain the essential elements described in the literature such as feedback, corrective loops and enrichment. Clear goals and timely feedback should be provided to maintain motivation. Deep learning is desirable and should be encouraged, although the student’s approach cannot easily be detected in an electronic system. Comprehension and vocabulary are areas where many students struggle partly as a result of language differences. The system must, therefore, present problems clearly and it must also allow for the mastery of a vocabulary of key words. Another essential prerequisite for e-mastery learning is appropriate computer literacy skills.

The following chapter presents the mastery learning system that was used in this study. Its strengths and weaknesses are reviewed in the light of the theoretical perspectives discussed in this chapter.

## Chapter 3: The intervention: A mastery learning system for quantity surveying students

This chapter presents the mastery learning system that was used as an intervention to help quantity surveying students at D.I.T. to achieve competency in key areas of the course. A description of the learning system will be presented and the main areas will be discussed. The strong and weak points of the system will be examined in the light of the theoretical background of Chapter 2.

The mastery learning system used in this experiment covered five content areas identified as problematic for the students concerned in this study, through the pilot test and other tests set by the department, as described in Chapter 1. These areas are mental arithmetic, mathematics, measuring, drawing interpretation and construction vocabulary. The mastery learning system comprises the exercises as shown in the following table and included in the appendices as indicated. The method of delivery was through the WebCT platform and on printed worksheets.

### 3.1 Content of the mastery system

	Description	Delivery	Appendix
<b>1. Mental arithmetic</b>			
$xx + y = ?$	Add a double digit number to a single digit number	WebCT	Not included in the appendix
$xxx + y = ?$	Add a triple digit number to a single digit number	WebCT	Not included in the appendix
$xx + yy = ?$	Add a double digit number to a double digit number	WebCT	Not included in the appendix
$xx - y = ?$	Subtract a single digit number from a double digit number	WebCT	Not included in the appendix
$x * y = ?$	Multiply a single digit number with a single digit number	WebCT	Not included in the appendix
$x * 25 = ?$	Multiply a single digit number with 25	WebCT	Not included in the appendix
<b>2. General mathematics</b>			
Areas and perimeters	Calculate the areas and perimeters of squares, rectangles, circles,	WebCT	D



	semi circles and triangles		
Triangles	Calculate hypotenuse and perpendicular height	WebCT	D
Volumes and surfaces	Calculate the volumes and surface areas of cubes, pyramids, wedges, cones and spheres	WebCT	D
Similar triangles	Given two lengths of one triangle and one length of the other triangle, calculate the unknown length	WebCT	D
Percentages	Convert decimal fractions to percentage and vice versa; do calculations using percentages	WebCT	D
Scale tutorial	Instruction and worked examples for understanding scale	WebCT	D
Scale	Convert from real-life size to scale size or vice versa. Given the real-life size and scale size, calculate the scale	WebCT	D
<b>3. Applied measuring</b>			
Exercise 1	1. Calculate the area of a shape with square sides  2. Calculate the area of a shape with curved sides	Print-based	E
Exercise 2	1. Calculate the area of a shape with square sides  2. Calculate the area of a shape with curved sides	Print-based	E
Exercise 3	Given an isometric view of a shape, calculate the volume and surface area	Print-based	E
Exercise 4	Given the plan of a roadway, calculate perimeters and areas	Print-based	E
Exercise 5	Given the plan of a flat roof, calculate perimeters and areas	Print-based	E
Exercise 6	Given an isometric view of a shape, calculate the volume and surface area	Print-based	E
<b>4. Drawing interpretation</b>			
Exercise 1	1. Given an isometric view, draw the plan, and two elevations  2. Given the plan, and two elevations, draw the isometric view	Print-based	F

	3. Given a photograph, draw the plan, two elevations and a cross section		
Exercise 2	1. Given an isometric view, draw the plan, and two elevations 2. Given the plan, and two elevations, draw the isometric view	Print-based	F
Exercise 3	Given an isometric view. draw the plan, and two elevations	Print-based	F
Exercise 4	Given an isometric view; draw the plan, two elevations and a cross section	Print-based	F
<b>5. Vocabulary in construction</b>			
Foundation section	Draw and annotate a strip footing from memory	Print-based	G
Eaves section	Draw and annotate an eaves cross section from memory	Print-based	G
Window and lintel section	Draw and annotate a window and lintel cross section from memory	Print-based	G

Table 1 List of mastery system components

### 3.2 Delivery: e-Mastery and print based

WebCT is a package of internet-based course tools. It allows educators to create content for students to access and use over the internet. It packages assessment tools, called “quizzes”, which test and score the student’s ability. The scoring is done automatically and results can be displayed on submission of each question or at the end of the quiz. The system also records the time and date that the student did the quiz, as well as the length of time taken to complete it. WebCT has an internal email system where the students can communicate with each other or with the lecturer. D.I.T trains and supports lecturers who use WebCT.

Since WebCT runs on the internet, it enables students and the lecturers to access the electronic classroom from any computer that has an internet connection at any time of their choosing.

In all of the mathematical exercises, the system changes the variables each time a student attempts the problems. In this way, correct answers cannot be memorised nor copied from another student. This ensures that students have to answer questions through their own working.

Some of the sections of the mastery learning programme were print-based. This means that the students received the questions printed on paper, they did their calculations on paper, and the lecturer marked them manually and provided verbal and written feedback. The students had an opportunity to re-do questions that they felt they could improve on. Due to time constraints in the development of the mastery learning system, some of the sections that could have been incorporated on the WebCT system had not yet been done. Some sections had to be delivered on paper, for example applied measuring exercises 1 and 2 (Appendix E), because the student was required to physically measure the shape presented on the page. The answer and feedback could, however, be given via WebCT. Some sections could be delivered via WebCT; however, the assessment and feedback could only be done manually, such as the drawing interpretation exercises.

### 3.3 Progressive levels of cognition

As discussed in Chapter 2, it is important for the exercises to be graded in an order that is progressive in terms of the levels of cognition. For example, the general mathematics exercise on areas and perimeters begins with simple length and area calculations which demonstrate the ability to *remember* and *understand* (Questions 1, 2, 3 and 4). The questions that follow these are more complex and intend to have students demonstrate the ability to *apply* what they know (Questions 6, 8, 11, 12). The exercise progresses to questions that require two levels of calculation (Questions 5 and 9). The final questions aim to demonstrate the ability to *analyse* and *create* a solution (Questions 14 and 15).

The general mathematics exercise (reproduced in Appendix D in its original format) has since been further revised. In keeping with the principles of mastery learning (Gusky 1988), this exercise has now been separated into three sections, where rectangles, circles and triangles are separate exercises. In this way, the area requiring remediation can be more precisely isolated. The order has also been adjusted for closer adherence to the levels of cognition, for example Questions 7 and 10, which demonstrate *remembering*, have been moved to the beginning of the circles exercise.

### **3.4 Motivation**

Chapter 2 introduced the concept of “optimal hedonic tone” where ideally a student should be able to regulate the pace of his or her own progress. A pace that is too slow would lead to boredom and a pace that is too fast would lead to anxiety. In principle, the e-based mastery system allows the student to progress at his or her own pace.

WebCT based exercises are assessed at the end of each session. The student who is extrinsically motivated by the scores that he or she achieves will enjoy the rapid feedback.

A further principle of mastery learning is that a student should be allowed repeated opportunities to improve his or her scores. The WebCT based system allows the student to repeat the exercises any number of times.

WebCT tracks each student’s marks (or scores), for every attempt that the student makes to improve on the results of an exercise. Both the student and the lecturer have access to the student’s marks. This facility gives the student a clear indication of his or her progress and serves to extrinsically motivate the student to further improve his or her scores. The intrinsically motivated student would find access via the internet, from home or D.I.T., an encouragement to study.

### **3.5 Formative assessment**

Rowntree (1977), quoted in Chapter 2, explained that students are very interested in how they are doing and effective feedback is important to them. This is confirmed by Strong et al. (1955) who expressed the view that it is more effective to give feedback soon after an assessment has been conducted rather than later. WebCT is able to give the scores immediately after the quiz is done, which is therefore most effective. To this end WebCT (2003 version) could provide feedback for right or wrong answers. However, in the case of a two or three step calculation, it could only tell the student if the final answer is right or wrong. To provide feedback for the intermediate steps would have been too complex and time consuming to develop at that stage. The intervention could therefore not provide this kind of feedback and was limited in its capacity to explain to the student *why* the answer was wrong.

### 3.6 Mastery and WebCT

Guskey (1988) explained that Bloom's model for mastery had the following stages: give instruction, give a formative assessment, diagnose the results, from the diagnosis provide individual feedback and individual remediation, allow the student to work on the remedial material, give assessment to discern if the student has mastered the section, and then either diagnose and provide further unique remediation or allow the student to begin the next section.

The use of WebCT for this mastery programme presented the following problems in relation to the above process. WebCT holds the links to instructional content on one page and the links to the assessments (quizzes) on a different page as illustrated in figure 10. By clicking on a link on the content page, the student can access the instructional material. However, the student has to find the relevant quiz that follows this instructional material on a different page. WebCT cannot, therefore, guide the student in a logical sequence from, for example, Content Area 1 to Quiz 1 to Content Area 2 to Quiz 2 and so forth. It simply shows links to the content areas on one page and links to the quizzes on a different page.

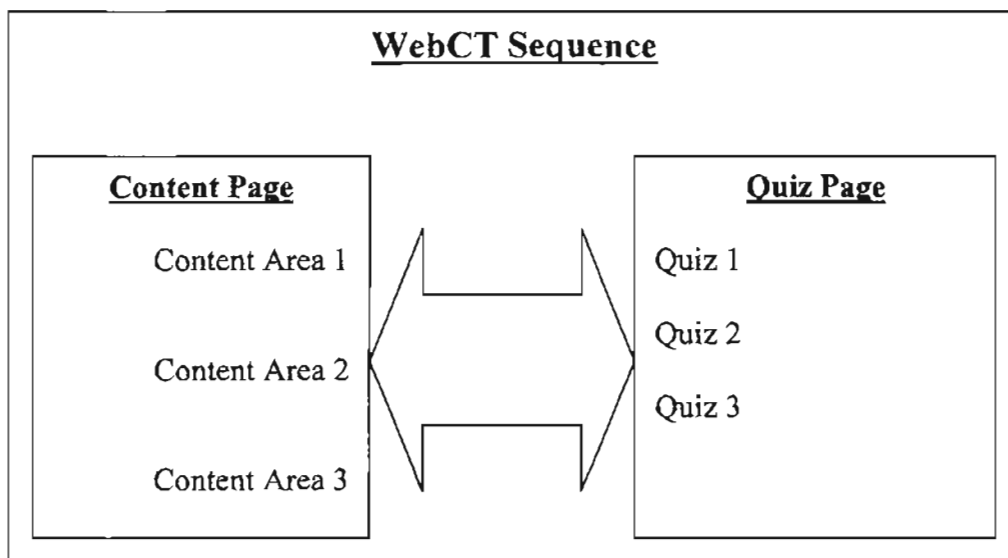
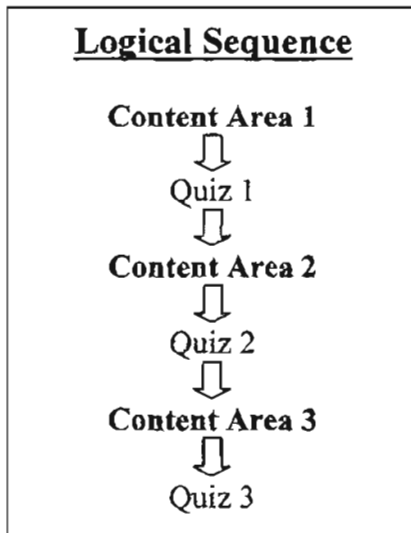


Figure 10: WebCT Sequence

The modules should be linked in a logical way that lead the student in the sequence that he or she should follow, as shown in figure 11, but WebCT does not have this capability.



**Figure 11: Mastery learning sequence**

Further it is not possible to route a student to a particular content area (e.g. a remedial content area) based on the result of their assessment. As stated above, the mastery model requires that the student must be given specific remediation if necessary or allowed to begin a new section depending on the result of the assessment.

### **3.7 Ongoing development**

The development of a mastery system to help D.I.T. quantity surveying students is an ongoing project. The author acknowledges that the system is not complete; there is a need to increase the number of questions in each section presented to date and also to increase the scope of the content. This study has described the mastery system as it was delivered in 2004 when it was used in this experiment.

### **3.8 Conclusion**

This chapter has explained the incorporation of learning theory and mastery principles in the mastery system, as it was developed and used in this experiment. It exposes limitations in the mastery material, as they occurred in the experiment, and the limitations of WebCT, the platform used to deliver the system. Further development of the mastery system is briefly mentioned.

Chapter 4 presents the methodology used to collect data regarding the performance of different student groups analysed in this experiment.

## **Chapter 4: Methodology**

Initially this study was conceived as a positivist enquiry into whether the introduction of a mastery system improves key competencies in quantity surveying students. As the research progressed it became evident that the positivist research approach only reveals part of how learning takes place and should be augmented by the collection and analysis of qualitative data.

In this chapter, the quantitative approach is discussed first, followed by the method of implementation of a mastery learning system and the methods of measuring students' improvement. The chapter then goes on to explain the additional qualitative approach and the collection of qualitative data which served to enrich the findings of the positivist approach.

### **4.1 Quantitative approach**

The quantitative approach involves the statistical measurement of the improvement of key competencies. Bell (1994:5) describes the approach as follows:

Quantitative researchers collect facts and study the relationship of one set of facts to another. They measure, using scientific techniques that are likely to produce quantified and, if possible, generalizable conclusions. (Bell, 1994:5)

Terre Blanche and Durrheim (1999:6) state that positivist research views the subject of research as a "stable and unchanging external reality" and that the researcher is detached from it.

In this study, the nature of the reality to be studied was regarded as a stable external reality where students' competence in a number of specific areas stated earlier, was tested and the results were statistically analysed. This presupposes that students were a stable reality and they would respond to the prescribed intervention in a consistent way. Furthermore, it implies that the results would reflect their ability in a reliable way.



The researcher would be a detached observer who would conduct the testing in controlled conditions and would then analyse the data with statistical tools. The research could be carried out in an objective way.

#### **4.1.1 Experiment design**

In order to come to a conclusion regarding the success or not of the intervention, an experiment was conducted where data were collected and analysed. The design of the experiment was governed by two factors, namely the availability of sample groups of students and ethical aspects. Three experiment designs are presented to explain the reasons for choosing the third design.

Cohen, Manion and Morrison (2000) explain that a “one group pre-test-post-test” is called a pre-experimental design. In this design, the sample group is tested prior to the intervention. The sample group is exposed to the intervention and then tested again. By comparing the results of the pre-test and post-test, conclusions about the success of the intervention can be drawn. The disadvantage of this design is that many variables outside the experimenters control may interfere with the results and it was therefore discarded as a design approach.

The pre-test post-test control group design, which is called a true experimental design, has a control group in addition to the experimental group. This design assumes that the external variables outside the experimenter’s control will affect both groups equally. Through analysis of the data collected from both groups, a conclusion may be drawn that discounts external variables. One difficulty with this design is to select two groups that are similar in ability. Large groups and random selection are recommended to ensure equivalence of the two groups. The context of the experiment did not allow the author to select from a large population.

It would have been unethical, in the author’s view, to allow half the class, which formed the experimental group, access to an intervention which was intended to improve their key competencies and disallow the other half of the class, which formed the control group, from this intervention. For this reason the true experimental design was also discarded as a design approach.

Cohen, Manion and Morrison (2000) describe a third design called a quasi-experimental design or the non-equivalent control group design. This design is adopted where it is not possible to select a control group and an experimental group randomly from a large population. The quasi-experimental design does, however, have a control group and is therefore a design that will eliminate some of the external variables that may affect the experiment.

For the purposes of this experiment, the one group pre-test-post-test design was rejected because it may be affected by external variables. The pre-test-post-test control group design was not possible because the class groups were not big enough to be split and because it would be unethical to withhold an improved learning system from some students. The non-equivalent control group design was therefore adopted for this experiment because it best suited the real-life context in which the intervention was to take place.

#### **4.1.2 Non-equivalent control group design**

The control group was the 2003 fourth year B.Tech quantity surveying class comprising 16 students. They wrote a pre-test; they were then exposed to a classroom-based face-to-face intervention comprising instructions and explanations of the material to be tested, and then they were subjected to a post-test.

The experimental group was the 2004 fourth-year B.Tech quantity surveying class comprising 8 students who wrote the same pre-test. The students were then exposed to a mastery system intervention and then subjected to the same post-test as the 2003 group. The collection of data was under controlled and timed classroom conditions and the results and conclusions were drawn from this quantitative data.

#### **4.1.3 The measurement of key competencies**

To be able to arrive at conclusions about students' competency levels the answers from the pre- and post-tests have to be measured. This section confronts the problems associated with measuring that involves human characteristics. It also discusses reliability and sampling.

## **Measurement of improvement**

To arrive at a conclusion about improvement, the improvement has to be measured. To be able to measure, a measuring instrument has to be defined that can measure observable attributes. To illustrate this, Hopkins and Antes (1985: 15) explain that the size of a room cannot be measured, but characteristics such as the length, width, volume, number of windows can be measured. Similarly human attributes such as popularity, enthusiasm or competence cannot be directly measured. Hopkins and Antes (1985: 15) define measurement as “a process that assigns by rule a numerical description to observation of some attribute of an object, person, or event.” The authors emphasise this difficulty in measuring human characteristics, but say that they can be overcome.

None of the human characteristics of importance to the educator can be measured with the soundness of physical measurement, because establishing correspondence to some external reality is highly unlikely. However, sharp definitions and highly valid measurement devices can provide valid information about characteristics which are important to the educational process. (ibid: 19)

In doing this research, three ways of measuring competence were considered. First a simple method of giving one mark for each correct answer, then adding them up and converting the total to a percentage. The second method used a more complex system adapted from Hopkins and Antes (ibid) who proposed measurement of units which reflect accurate measurement of the content areas and learning skills desired. However, although this system involved a complex process of weighting different questions relative to their levels of difficulty, it did not reveal any more information about the students' performance.

The third method evolved as a result of experimentations with the first and second methods given above. Questions were weighted and marks allocated according to the following rubric (Table 2). The students' answers marked accordingly, the marks totalled and presented as a percentage. This method had merit in its simplicity, and has been used consistently so that results are comparable. It also allowed the further analyses of each student's achievement at each level of cognition.

<b>Taxonomy level</b>	<b>Description</b>	<b>Mark allocation</b>
Remember	Recall an item of vocabulary, or a simple formula	1 mark
Understand	Demonstrate understanding of a concept	1 mark
Apply	Recall, understand and apply a formula or concept	2 marks
Apply two level calculation	Recall, understand and apply a formula or concept, but where the problem requires one calculation to be followed by another	4 marks
Analyse and apply	Be able to comprehend a sentence problem, split it into its relevant components and then apply a calculation to it	6 marks
Create	Use learned knowledge to create a unique solution	6 marks
Analyse, evaluate and create	Be able to comprehend a complex problem, analyse and evaluate the relevant information and create a unique solution	10 marks

**Table 2** Rubric for allocating marks

One weakness of a simple aggregate is that it does not reveal where the marks were scored. For example, a score of 50% can be achieved by scoring more or less 50% in all areas tested. However, a student can also achieve a 50% average score by scoring 80% in some areas and 20% in others. The analysis of the data must therefore go beyond looking at averages.

Most proponents of mastery learning, for example Mevarech (1988), set the criterion level of mastery at 80%. In this study 80% was also used as an indicator of competency. If a student achieves 80% or more he or she is considered to be competent. A score below 80% is considered incompetent.

### **Reliability**

“A test is reliable to the degree that it measures whatever it measures consistently” (Hopkins and Antes, 1979: 68). If, for example, a test of a student’s competence in a given area scores 68%, and later that same day the same student undertakes a different test on the same area, he should score the same 68%. These two tests can be considered reliable

instruments because although they use different questions they report the same degree of competence. There are many internal factors such as motivation, attitudes, physical health and emotional state of the student that will affect scores, as well as external factors such as temperature, lighting, noise level and interruptions. These factors are not all controllable by the lecturer but can affect the score and thus affect the measure of reliability. However, one way of improving the measure of reliability is to pilot the test beforehand.

### **Piloting**

A pilot test was compiled and tried out in 2002. After marking the students' responses this pilot test showed that

- Students needed more time and so the subsequent tests were shortened by half.
- Questions that required more than three levels of calculation were too difficult for most students so the subsequent tests questions were limited to two or three levels of calculation.
- The level of comprehension required by some of the questions confused the students so the subsequent tests questions were revised to be more straightforward.

Based on the findings of the pilot test, a pre-test and a post-test were then compiled, (See appendices H and I). The same pre-test and a post-test were used in 2003 and 2004. It was important that the two tests were equally difficult, and that they were reliable so that the difference in the pre- and post- tests scores indicated improvement or otherwise.

The revision of Bloom's taxonomy of educational objectives by Andersen and Krathwohl (2001) referred to in Chapter 1, names the levels of cognition as remember, understand, apply, analyse, evaluate and create. The questions in the pre- and post-tests have been categorised according to these five levels of cognition, and the assumption is that the levels of difficulty increase as the levels of cognition increase. The pre- and post- tests were compared for levels of difficulty and this analysis revealed that the post- test was more difficult than the pre- test because it had more of the "analyse, evaluate and create" type questions. This means that any improvement that the tests reveal will be *understated* for 2003 and 2004. This understatement is the same for both the 2003 and 2004 groups, because the same tests were used for both groups, thus providing a valid comparison.

### **Non-probability samples**

Cohen, Manion and Morrison (2000: 102) describe a non-probability sample as one where “the researcher targets a particular group, in the full knowledge that it does not represent the wider population; it simply represents itself.” They continue to say that this method of sampling is valid as long as no attempt to generalise the results is desired or made.

The researcher only had access to fourth year students in 2003, and consequently used the whole group as the control group. There were sixteen members in this group.

The experimental group of fourth year quantity surveying students in 2004 had eight members. This explains why the sample groups for this study were both small. Cohen, Manion and Morrison (2000) state that a sample size of thirty is commonly regarded as a minimum sample size if statistical analysis is intended. Due to the small sample sizes and the outcomes of the tests, it became necessary to augment the research with qualitative data.

#### **4.1.4 Statistical tools**

##### **Classical Test Theory**

The results of the pre- and post-tests were analysed by simply calculating group averages and observing the performance of individual students. This type of analysis is simple and does give an overall impression of the intervention’s performance. Hambleton & Swaminathan, (1991) caution that the Classical Test Theory (CTT) is limited because the groups’ ability and the tests’ difficulty must be similar for any valid conclusions to be made. For this reason the identical pre-tests were used each year, as well as identical post-tests. As mentioned earlier in this chapter, the post-test was more difficult than the pre-test, but since the same tests were used with both groups, the results may be compared. Also mentioned earlier in this chapter, in view of the non-probability samples, the results derived should not be generalised.

##### **Regression Analysis**

As a statistical tool, regression analysis, also referred to as residual analysis, uses a set of data pairs and fits them by using the least squares method to a straight line that can be presented on a graph. The formula for a straight line graph is:

$$Y = a + bX$$

where

Y = post test result

X is the pre-test result

*a* and *b* are constants determined by regression analysis as shown in Chapter 5

The resulting formula can be used to predict the expected performance “Y” of any student whose result from the pre-test “X”, is known. In the context of this study, the constants *a* and *b* are determined and the resulting formulae for the control group and the experimental group may be compared to predict which group’s performance is most enhanced by each intervention.

## 4.2 Qualitative approach

In order to implement and study a mastery system, a quantitative approach was initially adopted. It became evident, over time, that to implement a mastery system, the research of motivational factors required a more qualitative methodology.

Because different paradigms exist simultaneously, it is possible for the same researchers to draw on more than one paradigm, depending on the kind of work they are doing. (Terre Blanche and Durrheim 1999: 7)

It became apparent that the students did not perceive the mastery learning system as beneficial or interesting at that stage in their course. They were under extreme pressure from the other subjects that they were studying and many of them had personal issues that impacted on their lives during 2004. The research presented rich data on them as individuals, on what motivated them, and on how their backgrounds impacted on their studies. The following quote from Terre Blanche and Durrheim (ibid: 3) which prompts research to look “beyond the empirical evidence” to understand how a mastery system should be presented so as to most effectively help students, illustrates this point:

All research accounts are based on empirical data, and this is what methodology textbooks properly focus on. However, we can only partially understand accounts of the world by

referring to the facts and must look beyond empirical evidence to the background knowledge that makes the evidence believable. (Terre Blanche and Durrheim 1999:3).

They continue to explain that in circumstances where “the reality to be studied consists of people’s subjective experiences of the external world” (ibid: 6), it is quite legitimate for a researcher to adopt a more “intersubjective or interactional epistemological stance towards that reality” (ibid), making use of such methodologies as interviewing or participant observation, which is characteristic of the interpretative approach. Such an approach “aims to explain the subjective reasons and meanings that lie behind social actions” (ibid).

An interpretivist researcher would therefore have the following stance:

- Ontology: the reality that is being studied is the internal and subjective experience of each student.
- Epistemology: the researcher is involved and empathetic with the students. It is possible to get to know a group of eight students well.
- Methodology: Qualitative data would be collected through semi-structured interviews.

#### **4.2.1 Semi-structured interview**

Generally a distinction is made between three types of face-to-face interviews, as confirmed by Bell (1994) and Wragg (2002). These are the structured, the semi-structured and the unstructured interview. Wragg (ibid: 148) suggests that structured interviews are best used when a lot of questions are asked that are not particularly contentious or thought-provoking, whereas semi-structured interviews are more appropriate where the investigation ‘requires more profound deliberation’. He explains that the semi-structured interview is normally guided by a ‘carefully worded interview schedule’ (ibid: 149) but the interviewer may ask additional probing questions and make notes along the way, allowing the respondent to speak at length but within the parameters of the questions asked.

The selection of the semi-structured interview as one of the data collection tools in this study was guided by the following considerations:



- its adaptability and flexibility (Bell 1994): interviews can be adapted to time and place, and the interviewer can follow up ideas, probe responses and enable respondents to exercise greater control of the topic.
- Sensitivity and enrichment of data: the semi-structured interview allows for the expression of feelings which can be considered as positive aspects of the context and can affect interpretations (Mills 2001).
- Language barriers: many students in the group had English as a second language. The semi-structured interview would allow more flexibility for the student to understand the question and respond to it.

An interview schedule was developed, broadly covering five aspects that were judged pertinent to the research questions stated in Chapter 1, in particular questions four and five. The semi-structured interview permitted further questions to be asked to clarify the topics, as necessary. The interview schedule is in Appendix C. The aspects covered are:

*Personal details:* This aspect included information on student's educational background, previous qualifications and work experience.

*Pre-test:* Provided a record of the student's pre-test marks and their comments on how they felt about the pre-test and whether they felt improvement in these competencies would be useful.

*Computer literacy and access:* This aspect probes the student's ability to access the internet from both infrastructural and computer literacy points of view.

*Mastery programme:* The usefulness, the level of difficulty and other areas that may have been helpful were discussed for each area of learning.

*Quantity Surveying subject:* This aspect included the extent to which the mastery programme has been helpful in the quantity surveying subject.

### **4.2.2 Conduct of interviews**

The eight fourth year students of 2004 were interviewed on a one-on-one basis, towards the end of the academic year. These interviews took place in the computer laboratory while the other students were using the mastery programme. The responses, based on the five aspects described above, were compiled and analysed.

### **4.3 Conclusion**

This chapter has explained the two-fold approach to the research. The first part describes the quantitative approach and methods, tools and procedures used in the testing of the control group's and the experimental group's competencies to ascertain the improvement, or not, that the electronic mastery learning programme induces. The research was further augmented by a qualitative approach in order to complement the quantitative findings by using non-structured interviews.

Chapter 5 presents the data collected with regard to the application of the mastery learning system described in this chapter. The performances of the different student groups are compared. Students' impressions are gathered through semi-structured interviews with the experimental group, and the strengths and limitations of the experiment are discussed.

# **Chapter 5. Data collection and analysis**

## **5.1 Introduction**

As explained in Chapter 4, both quantitative and qualitative data were collected. This chapter describes how the data were collected, the application of the methods used to analyse the data, the findings and the conclusions that were drawn from the analysis. The chapter also includes an analysis of some of the data produced by WebCT during the intervention stage.

For the collection of quantitative data, the experiment was conducted over two years. The 2003 4th year B.Tech class was the control group. The 2004 4<sup>th</sup> year B.Tech class was the experimental group. There were no repeat students from 2003 in the 2004 group. The control group were subjected to a pre-test, a brief intervention and post-test. The experimental group was subjected to the same pre-test, a mastery intervention and the same post-test. The results and their implications form the basis of the findings and conclusions of this study.

The qualitative data derives from semi-structured interviews carried out with each student in the 2004 group.

## **5.2 Quantitative analysis**

The data was collected from the two groups over two years. Thereafter, two forms of statistical analyses were applied to the data. The data were first analysed by using Classical Test Theory (CTT). This gave an indication of trends. Thereafter a regression analysis was carried out on the data, as a means of confirming these trends.

### **5.2.1 Data Collection**

The four tests described below were taken under similar conditions, during lecture time. There was no time limit to the tests.

### **Control group 2003**

In 2003 there were sixteen fourth-year students. They took the “pre-test” (Appendix H) to assess their levels of key competency. This was done early in the year during regular lecture time. There was no time limit to the test. The results are shown in Appendix J

The intervention consisted of classroom-based face-to-face tuition. Each question was discussed and problem areas were highlighted. Students asked questions which were answered to the whole class. This intervention took place one week after the pre-test was taken and it was done over a two week period. Questions were not discussed more than once.

The “post-test” (Appendix I) was administered at the end of the year, during regular lecture time, to find out the extent to which the students had improved. There was also no time limit to this test. The results are shown in Appendix J.

### **Experimental group 2004**

As stated previously the experimental group consisted of eight students. The same pre-test used in 2003 (Appendix H) yielded the results shown in Appendix K. The mastery learning programme described in Chapter Four was introduced as an intervention to help the students improve on their key competencies. After six months of exposure to the intervention, the same post test used in 2003 (Appendix I) was administered. The results are shown in Appendix K

## **5.2.2 Data Analysis**

The data was analysed using two statistical tools, namely Classical Test Theory and Regression Analysis.

### **Application of Classical Test Theory**

The first statistical analysis on the data was done using simple CTT as described in chapter 5.

### **Control group 2003**

The results of the pre-test (Appendix J) ranged from 16% to 89%. Only two students attained a competency of over 80%.

The post test results are shown in appendix J. The results ranged from 35% to 96% indicating an improvement despite the post-test being slightly more difficult than the pre-test. The weakest students showed the most marked improvements. Five out of the group of sixteen attained a competency of over 80%. The average improvement of the whole group was 4%. The following table shows a summary of the results and the improvement of the group average as well as the weakest and strongest student.

2003	Pre test	Post test	Improvement
Mean	63%	67%	4%
Standard deviation	19%	19%	
Lowest student	16%	35%	19%
Highest student	89%	96%	7%
Competent (80%+)	2 students	5 students	19%

Table 3 Control group - average analysis

The study is concerned with helping individual students and, in particular, the weak students. The above analysis of averages does not indicate the progress of individuals. The following table shows the progress or regress that each student from the control group experienced. Where the movement was less than 3%, it was considered as insignificant and disregarded. The table shows that eight students improved, four did not change significantly and four did worse.

<b>Control group 2003</b>				
<b>Student</b>	<b>Pre test</b>	<b>Post test</b>	<b>Difference</b>	<b>Comment</b>
S1	16	42	26	improvement
S2	58	65	7	improvement
S3	73	80	7	improvement
S4	74	77	3	not significant
S5	65	43	-22	worse
S6	89	88	-1	not significant
S7	76	82	6	improvement
S8	68	66	-2	not significant
S9	88	76	-12	worse
S10	41	61	20	improvement
S11	40	35	-5	worse
S12	62	46	-16	worse
S13	71	96	25	improvement
S14	75	96	21	improvement
S15	46	47	1	not significant
S16	60	73	13	improvement

Table 4: Control group – comparison between pre-test and post-test

### *Experimental group 2004*

The results of the pre-test ranged from 24% to 85%. Only one student achieved over 80%.

After six months of the intervention, the post test (Appendix I) was administered. The results ranged from 30% to 94%. Three students achieved over 80%. The class average improved by 10%

The following table shows a summary of the results and the improvement of the group average, as well as the weakest and strongest student.

<b>2004</b>	<b>Pre test</b>	<b>Post test</b>	<b>Improvement</b>
<b>Mean</b>	54%	64%	10%
<b>Standard deviation</b>	22%	21%	
<b>Lowest student</b>	24%	30%	6%
<b>Highest student</b>	85%	94%	9%
<b>Competent (80%+)</b>	1 student	3 students	25%

Table 5 Experimental group - average analysis

Experimental group 2004					
Student	Pre test	Post test	Difference	Comment	
S1	30	40	10	improvement	
S2	62	82	20	improvement	
S3	32	47	15	improvement	
S4	85	94	9	improvement	
S5	73	82	9	improvement	
S6	24	30	6	improvement	
S7	79	74	-5	worse	
S8	51	62	11	improvement	

Table 6 Experimental group – comparison between pre-test and post-test

The above table shows that seven out of the eight students improved significantly. One student became worse. This student's case is discussed under the qualitative data section.

### Analysis of Levels of cognition

As discussed in chapter 2, levels of learning should be progressive. The pre-and post-test questions attempted to address the different levels of cognition shown in Table 7.

	2003			2004		
	Pre-test	Post-test	Gain	Pre-test	Post-test	Gain
	%	%	%	%	%	%
Remember and Understand	71	97	26	59	100	41
Apply	67	68	1	61	61	-
Analyse	19	56	37	38	53	15
Create	61	71	10	43	75	32

Table 7: Analysis of Levels of Cognition

The analysis of the pre- and post-test results, categorised according to Bloom's levels of cognition, revealed the following:

- the experimental group made greater gains in the lower levels, *remember* and *understand*
- both groups reached high levels of mastery in the *remember* and *understand* categories
- neither group made any significant gain in the *apply* category
- the only category in which the control group made more gain than the experimental group is the *analyse* category
- the experimental group improved significantly, compared to the control group in the highest level of cognition, namely *create*.

Overall the 2004 group gained in more of the categories than the 2003 group.

### **Conclusion of CTT analysis**

As stated in chapter 4, for statistical analysis of sample groups to be effective, sample sizes should exceed thirty. The results of the groups of sixteen and eight cannot be regarded as reliable. However, the results may be used to indicate the general trend of the effectiveness of the intervention.

The improvement on average of the experimental group (10%) exceeded that of the control group (4%). This improvement, greater by 6% is marginally significant in indicating that the e-mastery intervention helped students more; however the analysis of individuals further supports this hypothesis. Seven out of eight (87%) of the experimental group improved whereas only eight out of sixteen (50%) of the control group improved. Across cognitive categories, the experimental group, improved more than the control group.

The data was next analysed using Regression Analysis so that these conclusions could be confirmed.

### **Application of Regression Analysis**

The CTT analysis indicated that the intervention was helpful. A regression analysis was done to confirm this result.

The constants  $a$  and  $b$  in the formula for a straight line graph  $Y = a + bX$  are determined by regression analysis as described in Chapter 4 and the resultant formulae are as follows:

$Y = a + bX$  where  $a$  has been determined to be 0.75 and  $b$  as 19.9 the straight line graph formula becomes:

$$2003 \text{ post test result} = (0.75 \times \text{pre-test result}) + 19.9$$

and for 2004  $a$  has been determined to be 0.91 and  $b$  as 14.0 the formula becomes

$$2004 \text{ post test result} = (0.91 \times \text{pre-test result}) + 14.0$$

The resultant formulae can be used to theoretically predict the effect that each type of intervention would have on a student that has done the pre-test. The analysis results are shown in Figure 12.



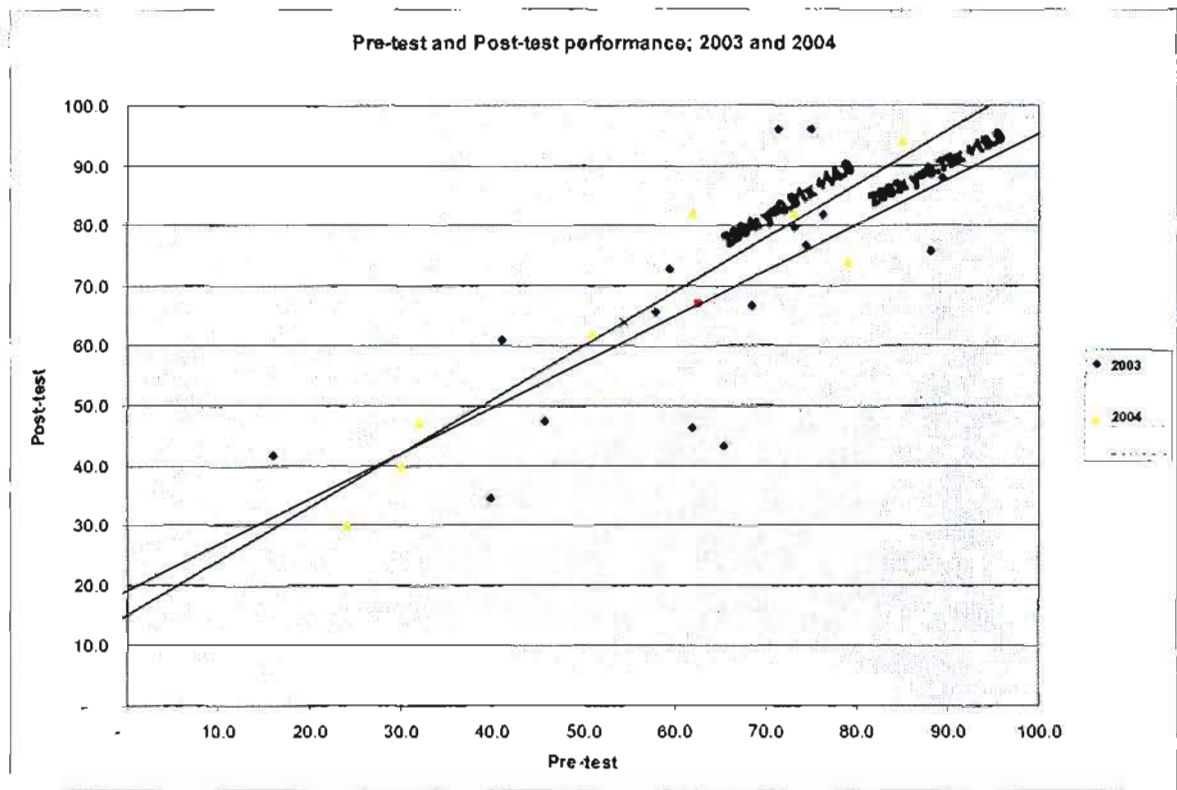


Figure 12: Graph illustrating pre-test and post-test performance; 2003, 2004

The regression analysis shows that any student who scores more than 30% in the pre-test (the point where the lines intersect on the graph) will benefit more from the 2004 intervention than from the 2003 intervention. For example a hypothetical student who has scored 60% in the pre-test is predicted to have post-test results as follows:

Subject to the 2003 face-to-face intervention: 65%

Subject to the 2004 mastery based intervention: 69%

He or she would thus, theoretically benefit 4% more from the 2004 intervention.

This analysis also shows that students scoring below 30% in the pre-test would be helped more by the face-to-face type intervention. This may be explained by problems they expressed in the interviews related to access to computer facilities and limited computer literacy. These issues are discussed more fully in the qualitative section of this chapter. As with CTT, Residual analysis is less reliable with small sample groups where one or two disparate pairs of data will affect the results. This analysis can, nonetheless, be used to indicate a trend, if viewed in conjunction with the CTT analysis.

### 5.2.3 Conclusion – quantitative analysis

Using the CTT analysis the conclusion was that the experimental group average improved by 6% compared to the control group and that more of the experimental group achieved mastery after the intervention. The Resgressional Analysis supported this finding showing that any student who gets more than 30% in the pre-test will benefit more from the mastery intervention than the face-to-face intervention.

#### WebCT data and analysis

The data that was collected and used for the experiment was discussed earlier in this chapter. During the 2004 intervention, the e-based mastery learning system produced additional data which revealed the strength of the e-based mastery system. WebCT records the scores and the time spent on each exercise that a student undertakes. There was no limit to the number of attempts a student could make to improve his or her scores. They were told to aim at a score of at least 80% for each exercise. The following table illustrates the groups' progress with the first General Mathematics exercise, Areas and Perimeters. Two students got 100% for the exercise and thus did not need to repeat the exercise. The rest of the group improved in both time and score. The most notable gain was S8 who started with a score of 50%, gained 42% over 4 attempts to finish with 94%. To achieve this level of mastery it took him a total of 42 minutes.

General mathematics - Areas and Perimeters							
Student	Worst attempt		Best attempt		Total Attempts number	Total Time minutes	Gain %
	Score %	Time minutes	Score %	Time minutes			
S1			100	1	1	10	
S2	82	11	94	7	7	67	12
S3	64	18	94	12	6	94	30
S4	52	29	64	17	2	30	12
S5			100	11	1	11	
S6	70	11	94	12	4	49	24
S7	33	11	54	11	3	34	21
S8	50	10	94	10	4	42	44

Table 8: WebCT data on General Mathematics: areas and perimeters exercise

The WebCT data revealed similar gains to those shown in Table 8, in the other exercises, where the student applied him or herself to the system. However, it also showed that some

students stopped working on an exercise before they reached the 80% level. Some students, particularly the weaker ones, did not attempt some exercises or only attempted them once. This indicated that they did not benefit fully from the system.

The author was, therefore, prompted to look further than statistical analysis to discover how the students received the web-based intervention.

### **5.3 Qualitative analysis**

The quantitative data reveals statistical results, but it cannot explain, for example why a particular student did worse after the intervention. Each student was interviewed to uncover their personal experiences at the Durban Institute of Technology (D.I.T.) and with the intervention. Their lives extend beyond key competencies, and their stories bring richness to this study that no amount of statistical analysis can give. This section describes the author's observations regarding motivation, and thereafter a report on the interviews which explain some of the reasons why the intervention did not work as well as expected.

#### **5.3.1 Observation regarding motivation**

As discussed in Chapter 2, motivation can be extrinsic or intrinsic. In the case of this particular class (Quantity Surveying 4, 2004), they generally displayed the symptoms of being extrinsically motivated by the promise of a qualification and the threat of failure. This was indicated by a keen interest in the course mark structure, which tests counted towards the year mark, and the scope of these tests. They showed minimal interest in enriching background facts, anecdotes and information that made the curriculum content more meaningful. Apart from one student, they consistently ignored any self-study or reflective work assigned unless it counted towards the final mark.

The mastery learning programme was introduced to the group after the pre-test revealed that they could all benefit from the intervention. The intervention was not enthusiastically received and, being extrinsically motivated, the students were not prepared to participate unless it contributed towards their final marks.

The intervention was voluntary and provided preparation for the post-test. The students were shown the open computer lab and were introduced to the system. The author

expected the group to enthusiastically take part in the mastery programme without much prompting, to gain access from home, from work or from the open labs at D.I.T. and proceed with the mastery programme in their own time. WebCT reported that there was no usage at all and that the group had simply ignored the system. The author encouraged the group by re-explaining the benefits of the mastery programme, but months slipped by with the minimum of participation from the students.

Due to the lack of intrinsic motivation and other inhibiting factors, described later in this section, lectures were rescheduled so that the mastery programme could be done once a week in class time. The new lecture and mastery schedule was negotiated with the students. When the given day arrived, most of them simply did not turn up. They appeared to consider that they were not missing any important lecture and took the morning off.

The above observation illustrates how important motivation is because such a mastery learning programme is of no benefit to students who do not feel motivated to use it.

### **5.3.2 Analysis of semi-structured interviews**

As stated before, this class was a small group that seemed motivated only to pass, and seemed to be strategic surface learners. The author had made assumptions about the students' ability to use an internet-based system, their motivation to use the system and the DIT's infrastructure to deliver the system. The mastery learning system was not enthusiastically received by the group. The semi-structured interviews were conducted to reveal the problems that the students faced and the reasons for their lack of enthusiasm.

Near the end of the academic year 2004, the eight students in the experimental group were interviewed. The interviews took place during lecture time, usually in the computer laboratory, while the other students were working on the e-mastery system. The interview schedule is shown in Appendix C.

The interviews revealed eight very real barriers that confounded the students *before* they could begin to benefit from a mastery learning system. The barriers are illustrated diagrammatically in Figure 13. The diagram indicates that the barriers are sequential,

which means that any single barrier that a student could not overcome would stop him or her from reaching the mastery programme.

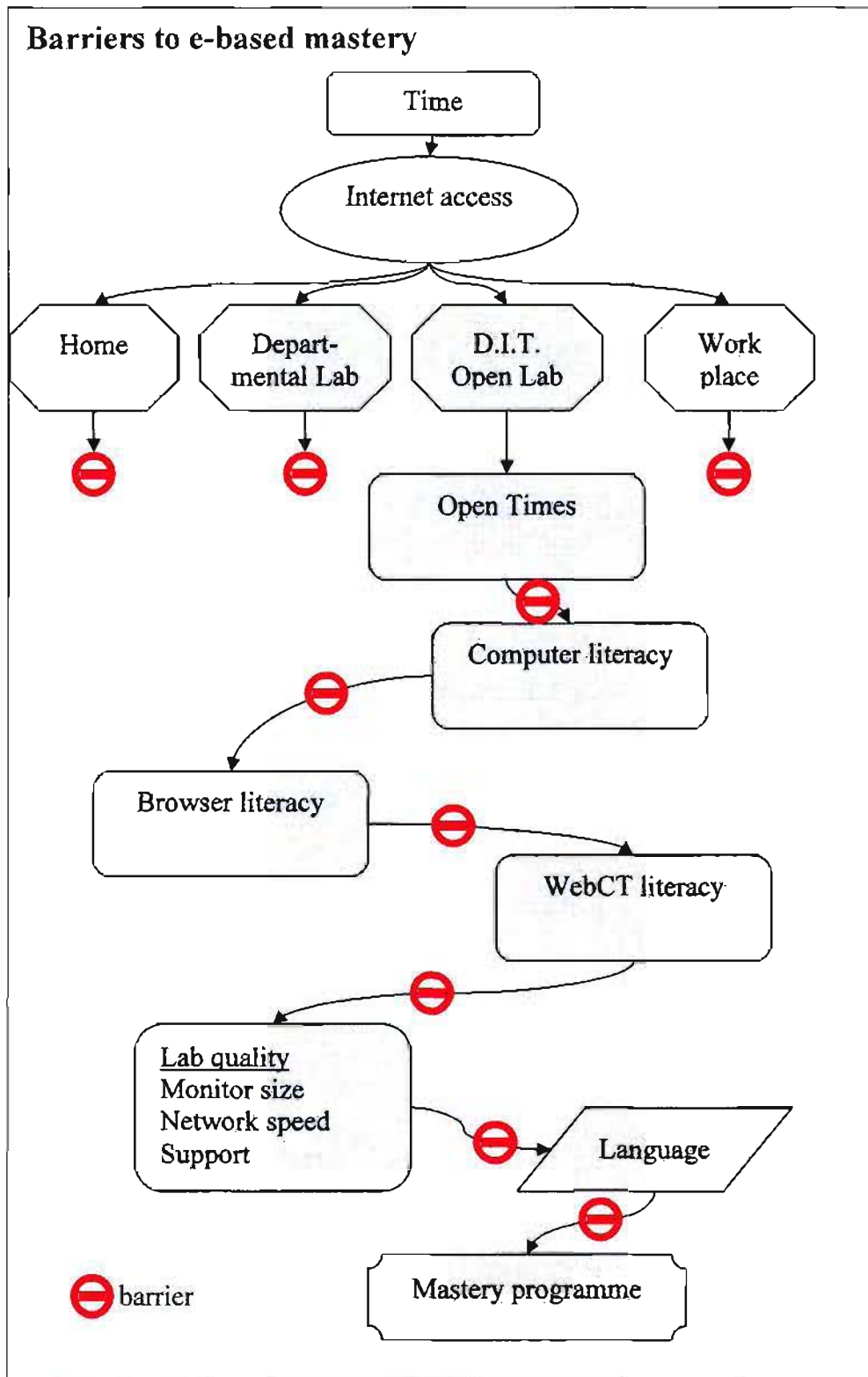


Figure 13: Barriers to e-based mastery

The results of the interviews are summarised below.

### **1. Time**

All the students in the 2004 experimental group were studying six subjects in that year. Three of them had part time quantity surveying jobs. Some had other work commitments. They reported that they were under constant time pressure and did not have enough time in each day to give each commitment the time it demanded. By studying the WebCT data, it was evident that the students very rarely spent time outside of lecture time on the e-mastery learning programme.

### **2. Internet access**

The proponents of WebCT at the D.I.T. give the impression that internet access is as accessible and free to students as it is to staff. It was on this basis that the author proceeded with the development of the e-mastery programme. The interviews revealed that no one in the group had internet access at home. Those who did have part-time work were not at liberty to use the office internet for study purposes. Internet cafés are available in the area and charged R20.00 per hour which was considered unaffordable by the group. Their only means of access was at D.I.T. facilities. The department had a computer laboratory, but for the whole of 2004 it was not operational as all the equipment was in storage as a result of the computer lab having to move premises. The only option for students was the open labs.

### **3. Open Lab access**

D.I.T. has three large computer labs which seat 30, 40 and 60 students, respectively. These venues are booked for lectures for most of the day. After 15h30, the venues are open to all students for until 21h30 in the evenings. The experimental group found this extremely limiting because they were often free when the labs were not open to them. One student complained that access to the open lab after 15h30 was of no use to her as the very latest that she could safely begin her homeward commute was at 16h00. She cited a recent Sunday newspaper article that identified the corner of Mansfield and Botanic Gardens road as a crime hotspot. The D.I.T. is bounded by these two roads. In

her case, crime in the area and the inconvenient lab opening times made the internet inaccessible to her.

A private security company controls access to the open labs. They are instructed to only let registered students in who have valid student cards. Up until 15h30 they only let in students who have scheduled lectures during that time. One student had difficulty in registering for financial reasons; he consequently did not have a student card and could not get access to the open labs. The author and the whole group were prevented, by the security guard, from entering, on one occasion. The correct arrangements had been made but had not been disseminated to the security guard. These two incidents illustrate the additional difficulty that the necessary but rigid security system places on students.

#### **4. Computer literacy**

Some members of the group had been exposed to computer usage at school and at home and therefore found computer usage natural and easy. However, four students were very unfamiliar and uncomfortable with using computers. They were inexperienced with keyboard and mouse usage, despite having reached fourth year. The course includes a non-credit bearing semester computer course in their first year, but this does not seem to be effective in orientating students in terms of computer literacy. The use of a computer may therefore be a barrier to some students.

#### **5. Browser literacy**

The use of a browser, such as Internet Explorer is another unfamiliar area. The concepts such as logging onto the Internet, URL's and favourites are new to some students. To get past this barrier, they need support and help.

#### **6. WebCT literacy**

WebCT has its own unique way of working. Five students reported that they found the use of WebCT difficult, particularly at the beginning of the intervention. They suggested that an orientation lesson where they are introduced to the basic use of WebCT, including showing students how to log into WebCT, the use of their user names and passwords, how to change passwords, how to view their progress, navigate

the menus and use the internal email and chat facilities would have been helpful. In this experiment these issues were treated on an ad-hoc basis.

## **7. Lab quality**

The equipment in the open lab was considered inadequate by all eight students. They complained about the computers' speed, the monitors, crowding, noise and defective computers. The labs were equipped with Pentium One computers and fourteen inch monitors. During the open times, they claim the venues were noisy and over-crowded. The facility was poorly managed and too small for the numbers of students who needed access. The network was very slow when all the computers were in use.

Three students pointed out that working the mathematics questions on the lab computers was difficult because they could not see the question, the variables and the diagram at the same time. They explained that this made it very difficult to calculate and answer a question without first copying some of it onto paper, before attempting to answer it. The reason that the lab computers presented the mastery questions so badly compared to the machines on which they had been developed and tested, is that the screens are cluttered with superfluous toolbars along the top, sides and bottom. Added to this, WebCT also has its own menus side bars, scroll bars and tool bars. In the end, the usable screen area where the question and its diagram are displayed was so small that the user had to scroll up, down, left and right to see the whole diagram and text. These students did not know that the unnecessary tool bars could easily be removed.

One high achieving student complained and asked for a paper print of the questions to work on at home and then to later enter the answers onto WebCT. This indicated a complete failure of the e-mastery concept. The access was so convoluted that the student wanted to circumvent the problem by having an intermediate paper based stage in the process. Because the objective of this experiment was to test an e-based system, they were not given paper prints of the questions.

One high achieving student lost interest in the mental arithmetic exercises because the open lab network was so slow that it could not absorb her answers as fast as she was giving them. For the mental arithmetic exercises, the students were encouraged to not



only improve on accuracy, but also on the time taken to complete the exercises. WebCT does report the time taken for each attempt at an exercise. The mastery concepts of rapid feedback and of the student being able to regulate her own pace was made ineffectual by the equipment.

## **8. Language**

The class consisted of four Zulu, one Xhosa, one Indian, one Swazi and one Afrikaans student. They have varying degrees of English literacy. Some had serious limitations in English comprehension. This was another significant barrier that made it difficult for some students to begin mastery learning as so much depended on self direction and good comprehension of the questions posed.

### **Case: Student S2**

Student S2 improved the most in the group. His pre-test was 62% and his post-test was 82%, indicating a gain of 20% in competency. In the interview he said that “I had forgotten most of this stuff that I learnt in school”. This fourth year student’s pre-test showed that the competencies that he had “forgotten” since school were, for example, how to calculate the area and circumference of a circle. (Question 3b,c and 4b and c) The pre-test identified and exposed his weak areas. The mastery system gave him an opportunity to gain competency and the post-test confirmed that he had achieved an above 80% level of competency.

### **Case: Student S7**

Student S7 was the only student that got worse. The author observed that her attendance of lectures and meeting assignment deadlines also deteriorated through the year. In the interview, she explained that she had had a particularly demanding traditional role to play in her cultural environment, and that had distracted her from her studies and the mastery learning system. She explained that her class marks for her various subjects had been good enough for her to pass despite this distraction and she could thus strategically “afford” to do worse than she had at the beginning of the year.

### **5.3.3 Conclusion – qualitative analysis**

The qualitative analysis, derived from semi-structured interview data, revealed that there were so many barriers to accessing the electronic intervention that it was almost inaccessible to many students. The reasons for the e-based system being almost inaccessible were broadly related to the D.I.T being poorly equipped and the students having problems of access, as well as varying levels of competency in computer literacy. It was therefore not simply a matter of students being demotivated and taking no interest in the programme.

The problem of students resisting e-based course work because of low levels of computer literacy is not unique to D.I.T. or South Africa, as Hoban et al (2003) reported the same problems at a medical school in America.

The author's own observations regarding motivation revealed that it cannot be assumed that students would be automatically motivated to use a mastery learning system. The course design of a successful intervention would have to be carefully planned to facilitate and enhance the motivation of the students.

## **5.4 Conclusion**

The statistical analysis of the quantitative data indicated that the electronic and paper-based mastery intervention is more helpful to students than a traditional classroom based face-to-face intervention. The data also revealed that many students in both groups were very weak in the identified key competencies and that they did benefit from the respective interventions. The qualitative research revealed that the mastery intervention could have been far more successful if factors external to the mastery system itself were addressed. It revealed that the e-based mastery system was largely out of reach for the students.

The analysis has shown that some form of intervention is necessary. An e-mastery learning system does have the potential to be helpful because it can be used at any chosen time and pace and gives rapid feedback; however, certain conditions must prevail as pre-requisites.

## Chapter 6. Conclusion

Students' poor performance, evidenced by the department's testing of mental arithmetic, the author's observation, and a pilot test led to this formal study on how to help students attain competency in certain key areas. The students' weaknesses in key competencies were validated in the pre-tests with both the 2003 and 2004 cohorts, where few students, only two out of sixteen and one out of eight respectively, displayed mastery in these key areas. The tests pointed to areas for improvement related to lower levels of cognition.

Mastery learning was identified as a methodology to use for helping students because it could be beneficial to slow and fast learners alike. This led to an investigation of mastery learning systems to help students improve their competence in some of the key areas identified through the tests. Due to human resource constraints, a computer based e-mastery learning system was conceived as an effective platform for the delivery of the programme. To test the efficacy of an e-based mastery learning system the question: "Does the introduction of an e-mastery system for quantity surveying students at the Durban Institute of Technology improve key competencies?" was formulated and investigated.

The objective of a quantitative study, based on a control group and an experimental group, each with a pre-test, intervention and post-test, was hampered by small sample sizes. The experiment was further constrained by difficulties for the students to access the e-mastery system. Nonetheless the quantitative results showed that the mastery intervention was helpful to students but not to the extent expected by the author..

Following this outcome a qualitative study was undertaken, in the form of semi-structured interviews, to ascertain why the e-based system was not as successful as expected. Although the quantitative analysis indicated that the e-based system was helpful, the interviews revealed a number of underlying problems, in particular access to the e-based system and students' limited computer literacy skills.

The research revealed that many of the students lacked confidence in using computers and internet based applications. For the implementation of any e-based education process the students need to be thoroughly grounded in computer literacy.

In addition to the issue of computer literacy, the research showed that the students did not have access at home where they could have comfortably worked on their mastery goals. The only access to the internet was through the D.I.T. open labs, during restricted times. A mastery learning principle is that each student should work at his or her own pace and time. This was not possible under the above circumstances. The research also revealed that the quality of access is important in terms of network speed and the quality of the equipment.

The data produced by WebCT during the intervention indicated that those students who did use the e-mastery system regularly and repeated the exercises as prescribed, did improve in the particular exercises. The conclusion drawn from these findings is that a e-based mastery learning system would help students improve their key competencies provided the computer literacy problems and access problems were solved and provided the students were motivated enough to devote themselves to using the system on a regular basis.

The following options are available to the department to help students achieve competency in key areas. It is therefore recommended that:

- The system be further developed by the department to increase the content.
- Each section of the system should have diverse remediation methods.
- The existing computer orientation course be upgraded to an effective computer literacy course.
- The intervention is applied early in the first year of study and is made a prerequisite for promotion to the second year of the course.
- The department provides a lab with appropriate equipment and where the students have access at convenient times.
- A software system that allows conditional branching based on quiz scores could be considered, so that remediation can be specifically directed.

Further research would also be required in order to increase the reliability and validity of the proposed e-mastery learning system. In particular a refinement of the pre-tests, post-tests and content questions to discriminate more accurately between the levels of cognition;

this should enrich the data on how the students progress with their mastery of key competencies. The test and content questions should also be refined so as to better distinguish between types of difficulty such as comprehension and/or calculation. First year classes are usually large, giving sample groups that will allow more reliable statistical analysis.

Ongoing development following the recommendations listed above, coupled with the further research proposals, will enhance the e-based mastery learning system, so as to help students attain mastery in the identified and essential key areas. This should result in the students being able to learn at higher levels of cognition and successfully graduate.

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## Appendices

## Appendix A. Mental Arithmetic

### BASIC NUMERICAL SKILLS TEST RESULTS

#### THE STUDENTS

A total of 106 students from the **Durban Institute of Technology** were tested. The breakdown of students were:

42 - 1<sup>st</sup> year Architects

41 - 2<sup>nd</sup> year Builders

23 - 3<sup>rd</sup> year Builders

Of the 106 students 96% had passed matric maths, 19% with Higher Grade.

#### THE TEST

The students were given the attached basic numerical skills test, which has 196 questions, and asked to answer as many as possible in 10 minutes.

#### THE RESULTS

The average number of questions answered was 56, one student answering only 4 questions!

Following is a breakdown of the answers to some of the questions.

- $11 \times 12$ : 41% answered incorrectly, answers including 108, 112, 120, 121, 122, 123, 124, 131, 133, 134, 136, 144, 148, 155, 222, 232, 330, 1010 and 11 200.
- $7 \times 8$ : 27% answered incorrectly, answers including 5, 20, 36, 46, 48, 49, 52, 54, 55, 57, 61, 64, 73, 79 and 114.
- $19 - 8$ : 11% answered incorrectly, answers including 8, 9 and 18.
- $4 \times 4$ : 13% of the 3<sup>rd</sup> year Builders answered incorrectly.
- $108 \div 9$ : 24% answered incorrectly, answers including 7, 8, 9, 10, 11, 13, 18, 19, 92 and 99.
- $54 \div 6$ : 31% answered incorrectly, answers including 6, 7, 8, 10, 11, 12 and 18.
- $9 \times 9$ : 24% of first year Architects answered incorrectly, answers including 18, 45, 54, 80, 82, 84, 88, 89, 98, 108, 121, 123
- $10 \times 11$ : 18% answered incorrectly.
- $49 \div 7$ : 14 % answered incorrectly, answers including 2, 4, 6, 8, 9, 42 and 61.

## Appendix B. Pilot Test

Student	Triangles	Irregular Triangles	Circles	Circles	Conversions	TOTAL	Average exceeds 80%
S1	100%	80%	100%	50%	100%	86%	over 80%
S2	100%	100%	100%	75%	89%	93%	over 80%
S3	100%	100%	100%	100%	100%	100%	over 80%
S4	60%	0%	31%	0%	89%	35%	-
S5	80%	60%	81%	25%	100%	68%	-
S6	60%	40%	69%	0%	89%	49%	-
S7	100%	100%	88%	50%	89%	85%	over 80%
S8	30%	0%	75%	50%	67%	45%	-
S9	75%	80%	88%	75%	100%	82%	over 80%
S10	80%	60%	69%	38%	89%	66%	-
S11	70%	80%	63%	0%	89%	56%	-
S12	90%	100%	75%	13%	56%	66%	-
S13	85%	80%	75%	38%	100%	73%	-
S14	80%	100%	44%	25%	33%	56%	-
<b>AVERAGE</b>	79%	70%	75%	38%	85%	69%	

Pilot test 2002

## Appendix C. Interview Schedule

<b>Date of interview</b>	
<b>Personal details</b>	
Name	
Sex	
Age	
Mother tongue	
School	
Diploma	At which institute did you get your diploma
Marks	What were your marks like on average
Work experience	Where did you do your work experience; do you currently work
<b>Pre test</b>	
Mark	
Comments	How did you find the pre-test, do you feel you need to improve your competence
<b>Computer literacy and access</b>	
WebCT and Internet explorer	Are you familiar with internet explorer Do you find WebCT easy to use
Computer labs	Comment on the equipment, support and open time
Internet access	Do you have access at home, work or elsewhere?
<b>Mastery programme</b>	
Mental arithmetic	How did you find this section in terms of difficulty and usefulness? Do you feel that it would help you improve
Maths	How did you find this section in terms of difficulty and usefulness? Do you feel that it would help you improve
Measuring	How did you find this section in terms of difficulty and usefulness? Do you feel that it would help you improve
Drawing interpretation	How did you find this section in terms of difficulty and usefulness? Do you feel that it would help you improve
Vocabulary	How did you find this section in terms of difficulty and usefulness? Do you feel that it would help you improve
<b>Quantity surveying subject</b>	How does the above content supplement the subject
Year mark	Your year mark for quantity surveying

# Appendix D. General Mathematics

## Areas and perimeters

### General mathematics – Areas and Perimeters

Name: Eric Frank (Preview)

Start time: February 12, 2004 4:01pm

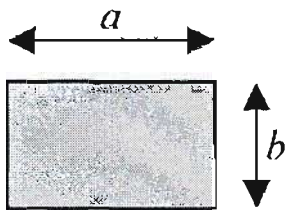
Number of questions: 15

Question 1 (2 points)

$$a=17m$$

$$b=5m$$

Calculate the area of the rectangle.....



Answer: \_\_\_\_\_

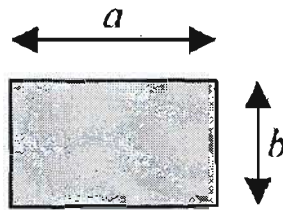
Units: \_\_\_\_\_

Question 2 (2 points)

$$a=21m$$

$$b=6m$$

Calculate the perimeter of the rectangle.....



Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 3 (2 points)

$$a=6m$$

Calculate the area of the square....



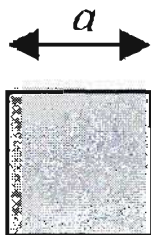
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 4 (2 points)

$$a=25m$$

Calculate the perimeter of the square....



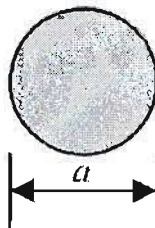
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 5 (2 points)

$$a=15m$$

Calculate the area of the circle shown, where the diameter is 15m ...



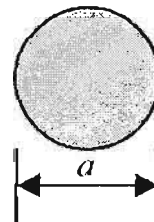
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 6 (2 points)

$$a=17m$$

Calculate the circumference of the circle, where the diameter is 17 m....



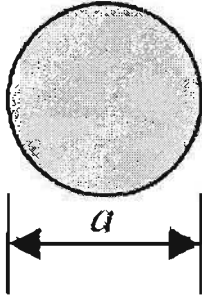
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 7 (1 point)

$a=17\text{m}$

Calculate the radius of the circle....



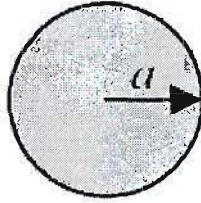
Answer:

Units:

Question 8 (2 points)

$a=20\text{m}$

Calculate the area of the circle....



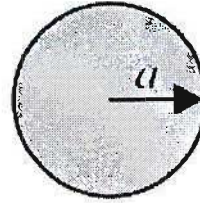
Answer:

Units:

Question 9 (2 points)

$a=18\text{m}$

Calculate the circumference of the circle....



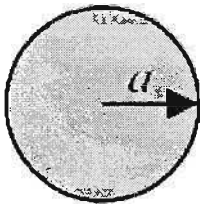
Answer:

Units:

Question 10 (1 points)

$a=14.4\text{m}$

Calculate the diameter of the circle....



Answer:

Units:

Question 11 (2 points)

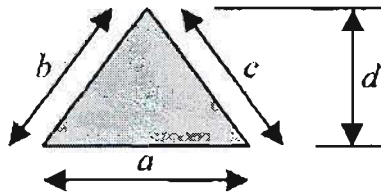
$a=3\text{m}$

$b=3\text{m}$

$c=5\text{m}$

$d=23\text{m}$

Calculate the area of the triangle....



Answer:

Units:

Question 12 (2 points)

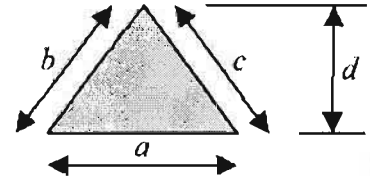
$a=11\text{m}$

$b=14\text{m}$

$c=12\text{m}$

$d=5\text{m}$

Calculate the perimeter of the triangle....



Answer:

Units:



Question 7 (1 point)

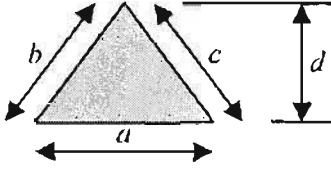
$a=14\text{m}$

$b=14\text{m}$

$c=23\text{m}$

$d=9\text{m}$

If "a" is the base what is the perpendicular height of the triangle?



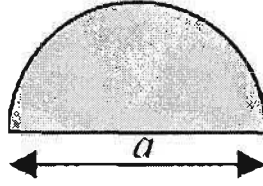
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 8 (2 points)

$a=17\text{m}$

Calculate the area of the semi-circle....



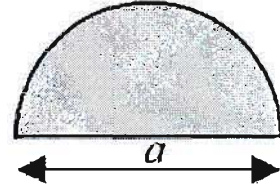
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 9 (2 points)

$a=4\text{m}$

Calculate the perimeter of the semi-circle....



Answer: \_\_\_\_\_

Units: \_\_\_\_\_

# Triangles

## General mathematics - Triangles

Name: Eric Frank (Preview)

Start time: February 12, 2004 4:01pm

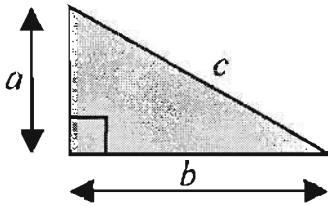
Number of questions: 5

**Question 1 (1 point)**

$a=16m$

$b=4m$

Calculate the hypotenuse of the triangle...

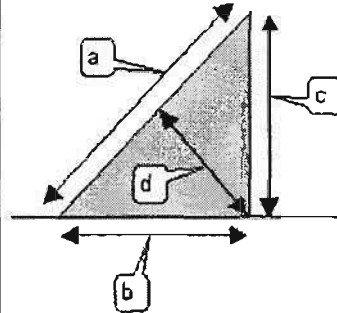


Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 2 (1 points)**

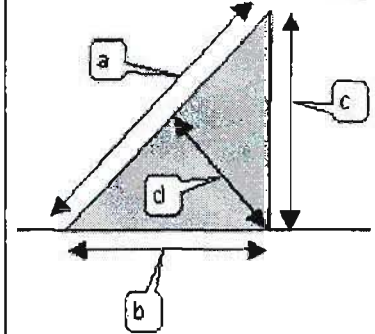
If the base of the triangle is "c", what is the perpendicular height?



Answer: \_\_\_\_\_

**Question 3 (1 points)**

If the base of the triangle is "a", what is the perpendicular height?

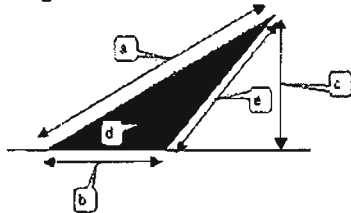


Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 4 (1 point)**

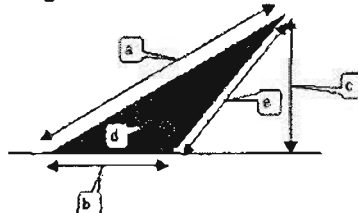
If the base of the triangle is "b", what is the perpendicular height?



Answer: \_\_\_\_\_

**Question 5 (1 point)**

If the base of the triangle is "a", what is the perpendicular height?



Answer: \_\_\_\_\_

# Volumes and surfaces

## General mathematics – Volumes and surfaces

Name: Eric Frank (Preview)

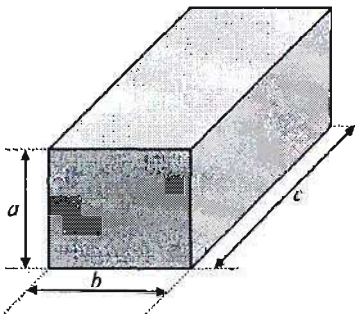
Start time: February 12, 2004 4:01pm

Number of questions: 11

**Question 1 (2 points)**

$a=16\text{m}$   $b=14\text{m}$   $c=5\text{m}$

Calculate the volume of the rectangular solid....



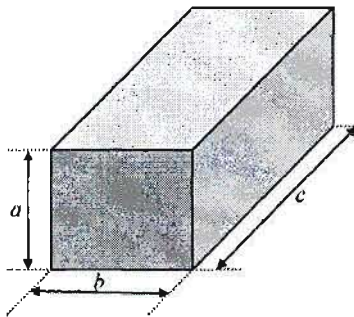
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 2 (2 points)**

$a=11\text{m}$   $b=6\text{m}$   $c=17\text{m}$

Calculate the surface area of the rectangular solid....



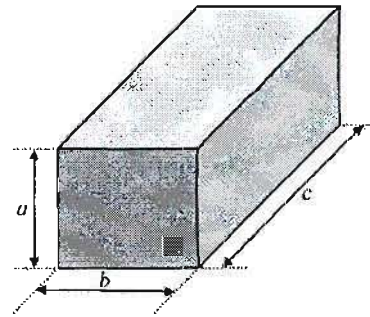
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 3 (2 points)**

$a=10\text{m}$   $b=5\text{m}$   $c=15\text{m}$

Calculate the length of all the edges of the rectangular solid....



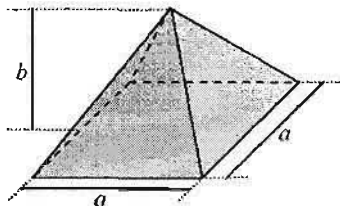
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 4 (2 points)**

$a=24\text{ m}$   $b= 16\text{ m}$

Calculate the volume of the pyramid....



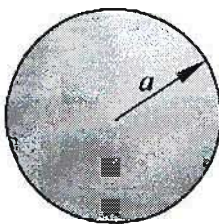
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 5 (2 points)**

$a=11\text{ m}$

Calculate the volume of the sphere....



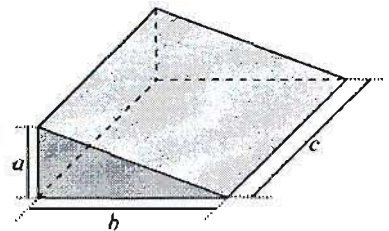
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

**Question 6 (2 points)**

$a=19\text{m}$   $b=13\text{m}$   $c=17\text{m}$

Calculate the volume of the wedge....



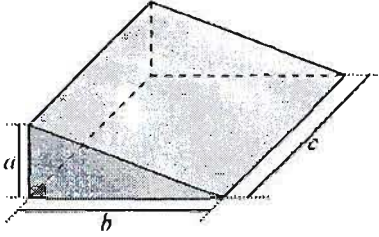
Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 1 (2 points)

$a=4\text{m}$   $b=17\text{m}$   $c=4\text{m}$

Calculate the surface area of the wedge....



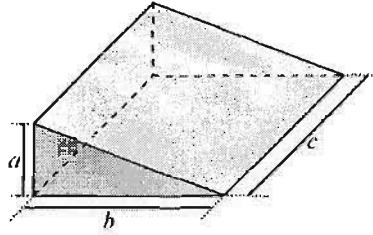
Answer:

Units:

Question 1 (2 points)

$a=3\text{m}$   $b=9\text{m}$   $c=21\text{m}$

Calculate the length of all the edges of the wedge....



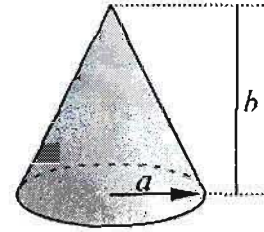
Answer:

Units:

Question 1 (2 points)

$a=11\text{m}$   $b=16\text{m}$

Calculate the volume of the cone....



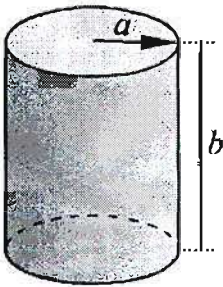
Answer:

Units:

Question 1 (2 points)

$a=2\text{m}$   $b=20\text{m}$

Calculate the volume of the cylinder....



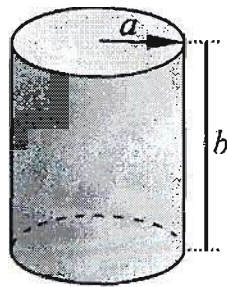
Answer:

Units:

Question 1 (2 points)

$a=6\text{m}$   $b=23\text{m}$

Calculate the area of the curved surface of the cylinder....



Answer:

Units:

## Similar triangles

### General mathematics – Similar triangles

Name: Eric Frank (Preview)

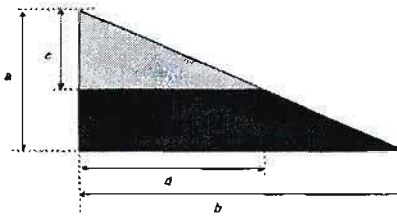
Start time: October 11, 2004 13:49pm

Number of questions: 13

Question 1 (2 points)

$$a = 5\text{m} \quad b = 8\text{m} \quad c = 2.2\text{m}$$

Calculate the length of "d".



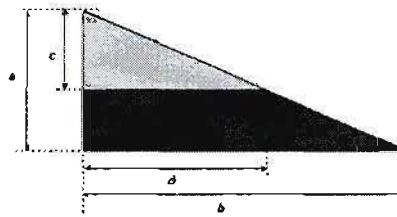
Answer:

Units:

Question 2 (2 points)

$$a = 10\text{m} \quad b = 14\text{m} \quad c = 2.8\text{m}$$

Calculate the length of "c".



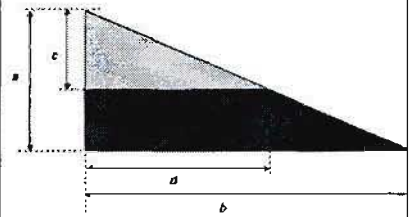
Answer:

Units:

Question 3 (2 points)

$$a = 9\text{m} \quad c = 7\text{m} \quad d = 12\text{m}$$

Calculate the length of "b".



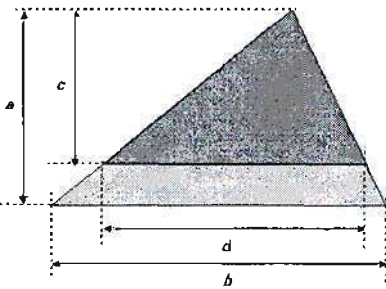
Answer:

Units:

Question 4 (2 points)

$$a = 7\text{m} \quad b = 10\text{m} \quad c = 2.4\text{m}$$

Calculate the length of "d".



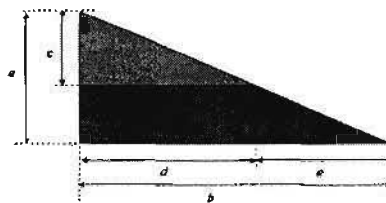
Answer:

Units:

Question 5 (2 points)

$$a = 5\text{m} \quad b = 8\text{m} \quad e = 3.6\text{m}$$

Calculate the length of "c".



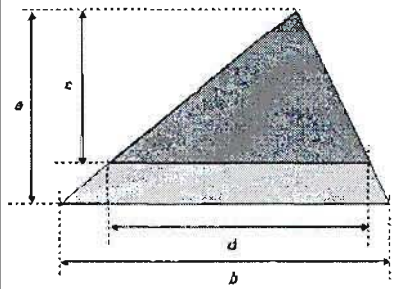
Answer:

Units:

Question 6 (2 points)

$$a = 9\text{m} \quad b = 12\text{m} \quad d = 2.6\text{m}$$

Calculate the length of "c".



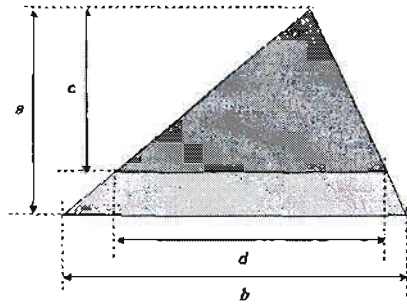
Answer:

Units:

**Question 7 (2 points)**

$a = 15.0\text{m}$   $c = 6\text{m}$   $d = 9\text{m}$

Calculate the length of "b".



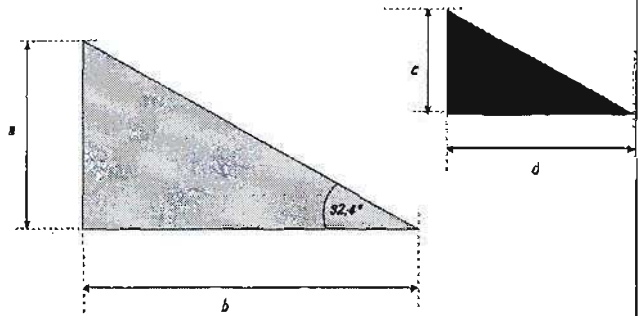
Answer:

Units:

**Question 8 (2 points)**

$a = 3\text{m}$   $b = 6\text{m}$   $c = 1.4\text{m}$

Calculate the length of "d".



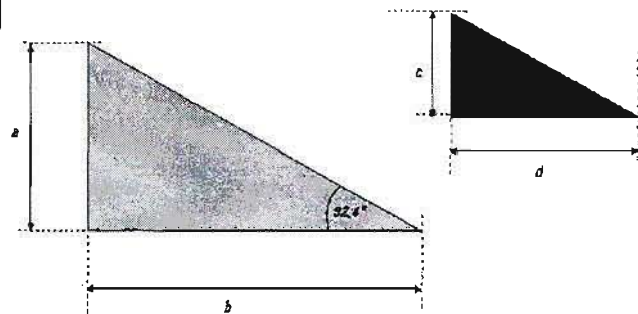
Answer:

Units:

**Question 9 (2 points)**

$a = 2\text{m}$   $b = 5\text{m}$   $d = 1.0\text{m}$

Calculate the length of "c".



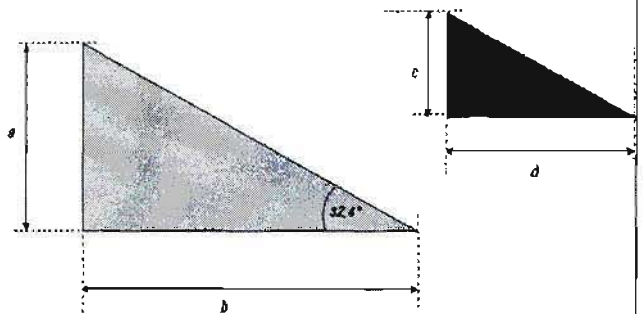
Answer:

Units:

**Question 10 (2 points)**

$a = 15\text{m}$   $c = 5\text{m}$   $d = 8\text{m}$

Calculate the length of "b".



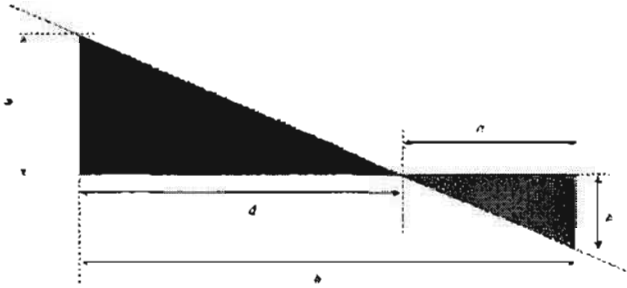
Answer:

Units:

Question 11 (2 points)

$a = 5\text{m}$   $b = 14\text{m}$   $e = 2\text{m}$

Calculate the length of "c".



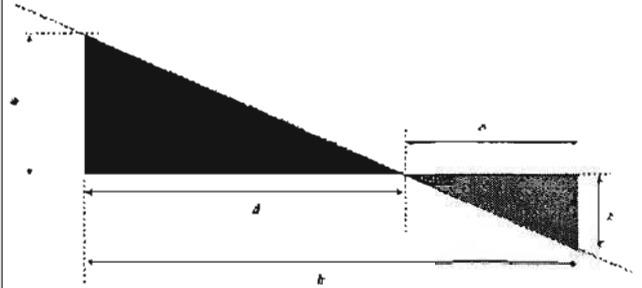
Answer:

Units:

Question 12 (2 points)

$a = 8\text{m}$   $b = 28\text{m}$   $c = 4.0\text{m}$

Calculate the length of "d".



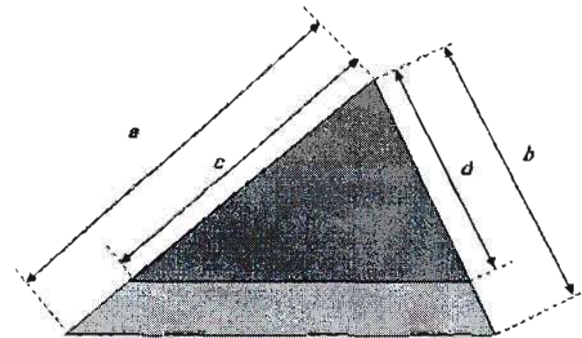
Answer:

Units:

Question 13 (2 points)

$a = 5\text{m}$   $b = 4.0\text{m}$   $c = 4.0\text{m}$

Calculate the length of "d".



Answer:

Units:

## Percentages

### General mathematics – Percentages

Name: Eric Frank (Preview)

Start time: October 11, 2004 13:41 pm

Number of questions: 11

**Question 1** (2 points)

Write 1.78 as a percentage

Answer:

**Question 2** (2 points)

Write 0.7% as a decimal fraction

Answer:

**Question 3** (2 points)

Write 117% as a decimal fraction

Answer:

**Question 4** (2 points)

Write 11% as a decimal fraction

Answer:

**Question 5** (3 points)

The price of an article is R28.87 inclusive of V.A.T. (14%) How much does the article cost net of V.A.T.

Answer:

**Question 6** (3 points)

The price of an article is R52.70 inclusive of V.A.T. (14%) How much does the article cost net of V.A.T.

Answer:

**Question 7** (4 points)

The price of an article is R89.44 inclusive of V.A.T. (14%) How much is the V.A.T. on the article?

Answer:

**Question 8** (4 points)

The price of an article is R114.33 inclusive of V.A.T. (14%) How much is the V.A.T. on the article?

Answer:



**Question 9** (3 points)

A 15% service charge has been added to a bill. The bill, inclusive of the service charge is R169.71 How much is the bill net of the service charge?

Answer:

**Question 10** (4 points)

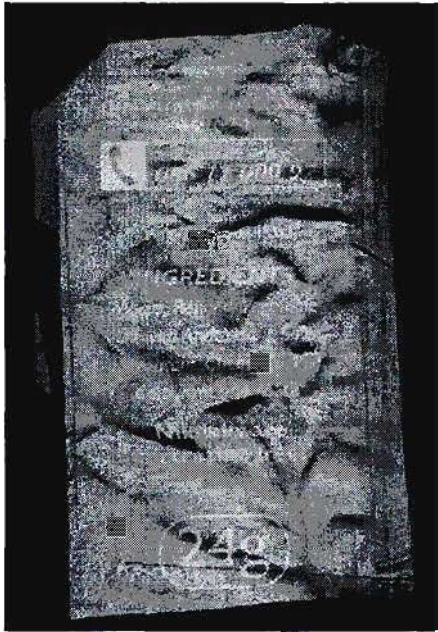
An allowance of 3 % hard rock has been used in a bill of quantities.

The hard rock shown in the bill is 44m<sup>3</sup>

How much should the total volume of the excavations be?

Answer:

**Question 11** (6 points)



As you already know Niknaks contain real cheese! The picture shows the ingredients on a 24g packet of Niknaks. They contain 0.1% cheese. How many kilograms of Niknaks could you make out of 1Kg of cheese?

Answer:

## Scale tutorial

### Scale - elementary

As a quantity surveyor it is essential that you understand scales well.

There are three variables associated with scale:

- the real life measurement
- the measurement on the drawing
- the scale (i.e. the ratio at which these two measurements relate to each other)

Given any two of the above variables you must be able to work out the third one.

Scale is given in the following format "1:100" This means that 1 unit on the drawing is equal to 100 units in real life. Remember that the drawing's unit comes first. "Drawing : Real life"

#### Example 1:

(DxL)

A door is 2000mm high in real life and is measures 20mm on a drawing. What scale is the drawing?

Answer: 2000 divided by 20 = 100 Scale is 1: 100

#### Example 2:

(xRL)

A door is 2000mm high in real life. The drawing's scale is 1:50. How high should the door be on the drawing?

Answer: 2000 divide by 50 = 40mm

#### Example 3:

(DRx)

A parking place measures 25mm on a drawing, The drawing's scale is 1:200. How long is the parking place in real life?

Answer: 25mm times 200 = 5000mm

### Scale - intermediate

A scale does not need a unit to define it. It is simply a ratio. "1:100"

In words "1:100" could be described as "1mm on the drawing represents 100mm in real life."

But it would be equally true to say of the same drawing that "1cm on the drawing represents 100cm in real life" or

"1 inch on the drawing represents 100 inches in real life"

**Take careful note** that the units are the *same on each side of the ratio*. Eg 1mm represents 100mm

In very large scales the units may be mixed. A drawing that shows the scale as "1mm: 10m" is very confusing. The scale is actually 1:10 000

It is important that you understand this concept thoroughly.

#### Example 1:

A drawing shows the scale as 1cm:10m. What is the scale?

Answer: 10mm: 10 000mm **thus** 1:1000

#### Example 2:

A drawing shows the scale as 2cm:1km. What is the scale?

Answer: 20mm: 1000 000mm **thus** 1:50 000

#### Example 3:

A gate is 5m wide in real life and measures 1mm on a drawing. What scale is the drawing?

Answer: 5000 divided by 1 = 5000 Scale is 1: 5000

#### Example 4:

A road is 1500 m long in real life. The drawing's scale is shown as "1cm:1km. How long should the road be on the drawing?

Answer: Step 1: Calculate the scale ==> The true scale is 10:1 000 000 thus 1: 100 000.

Step 2: Calculate the length of the road in mm 1500m x 1000 = 1 500 000mm

Step 3: Divide 1 500 000mm by 100 000 = 15mm

The road should be 15mm long on the drawing

## Scale

### Scale - level 1

Name: Eric Frank (Preview)

Start time: October 11, 2004 13:44

Number of questions: 12

*As a quantity surveyor it is essential that you understand scales well.*

*You should aim to get 100% for this test.*

*If you have any difficulty in understanding the concepts tested here refer to "Scale-elementary" in the content section. You may use a calculator*

#### Question 1 (2 points)

Fill in the missing information:

Drawing	Scale	Real life
174mm	1: ??	87000mm

Answer:

#### Question 2 (2 points)

Fill in the missing information:

Drawing	Scale	Real life
?? mm	1: 25	2800mm

Answer:

Units:

#### Question 3 (2 points)

Fill in the missing information:

Drawing	Scale	Real life
142 mm	1: 500	??mm

Answer:

Units:

Question 4 (2 points)

Fill in the missing information:

<u>Drawing</u>	<u>Scale</u>	<u>Real life</u>
6 mm	1: 5	??mm

Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 5 (2 points)

Fill in the missing information:

<u>Drawing</u>	<u>Scale</u>	<u>Real life</u>
124 mm	1: 25	??mm

Answer: \_\_\_\_\_

Units: \_\_\_\_\_

Question 6 (2 points)

Fill in the missing information:

<u>Drawing</u>	<u>Scale</u>	<u>Real life</u>
136mm	1: ??	6800mm

Answer: \_\_\_\_\_

Question 7 (2 points)

Fill in the missing information:

<u>Drawing</u>	<u>Scale</u>	<u>Real life</u>
30mm	1: ??	750mm

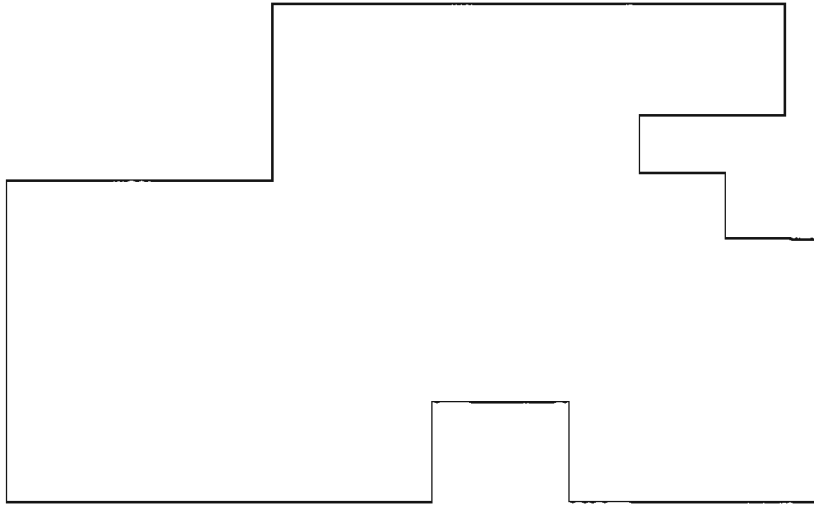
Answer: \_\_\_\_\_

# Appendix E

## Applied measuring exercise one

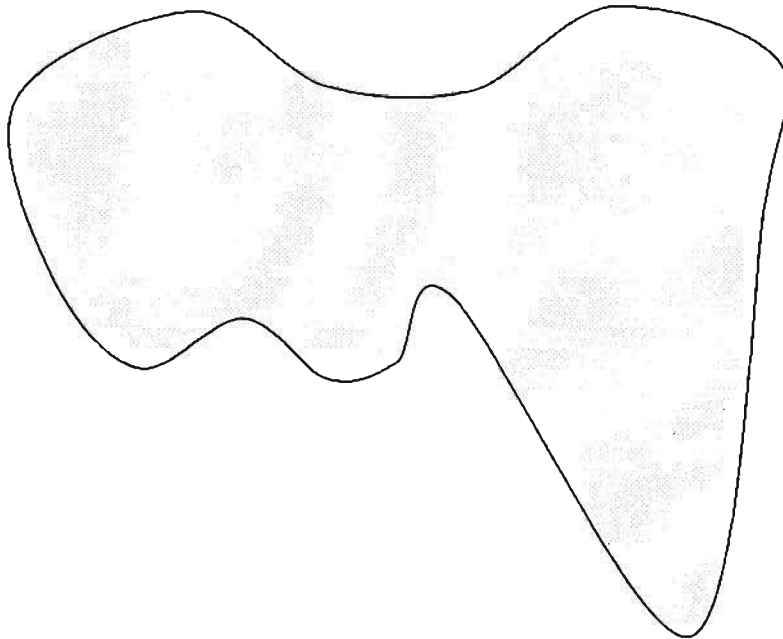
Name : \_\_\_\_\_

1. Calculate area of this shape.



Give your answer in mm<sup>2</sup>  
Give a full record of your calculations

2. Calculate area of this shape.



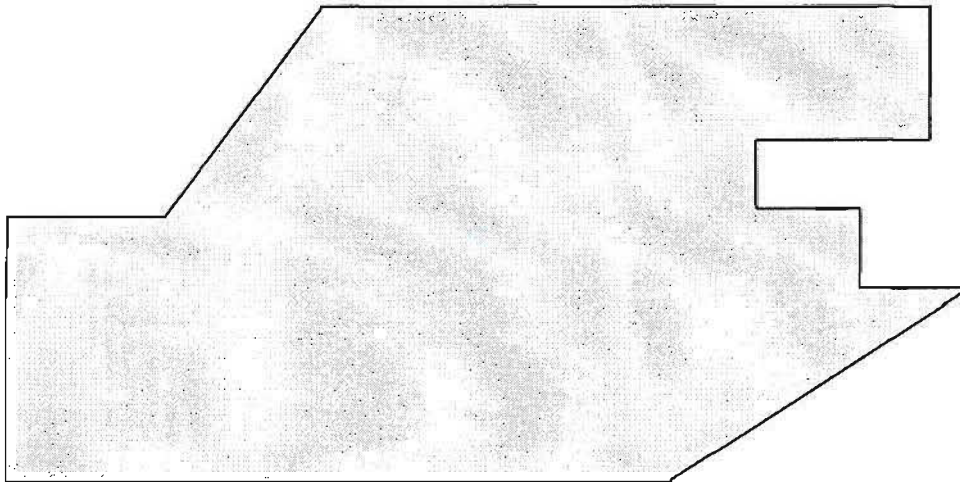
Give your answer in mm<sup>2</sup>  
Give a full record of your calculations

.....  
.....  
.....

## Applied measuring exercise two

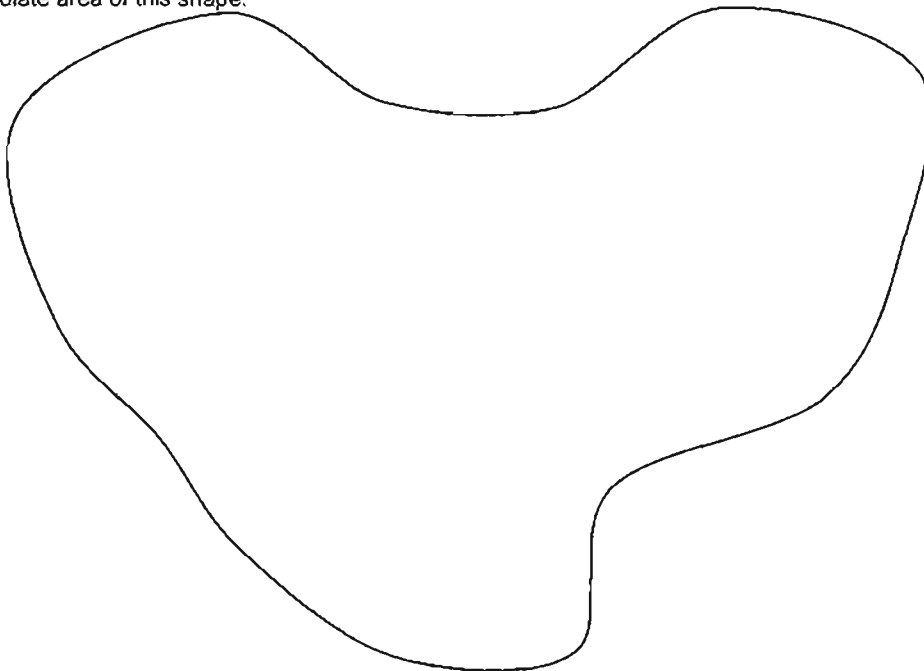
Name : \_\_\_\_\_

1. Calculate area of this shape.

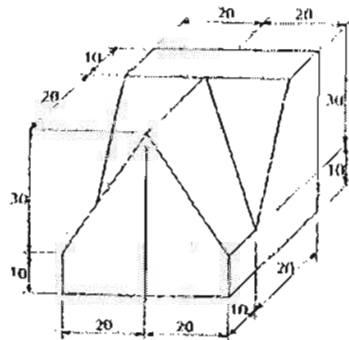


Give your answer in mm<sup>2</sup>  
Give a full record of your calculations

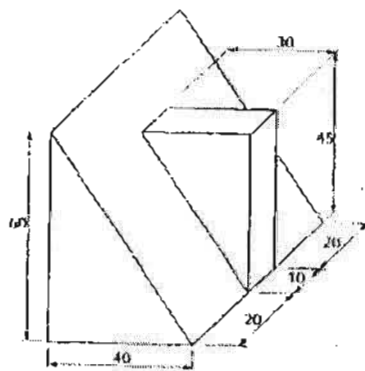
2. Calculate area of this shape.



**Applied measuring exercise three**

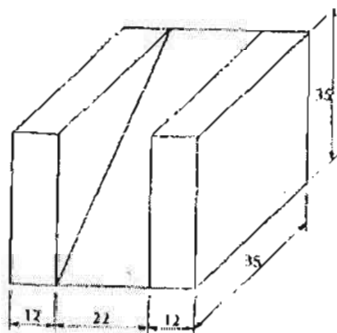


1. Calculate the volume:



2. Calculate the volume

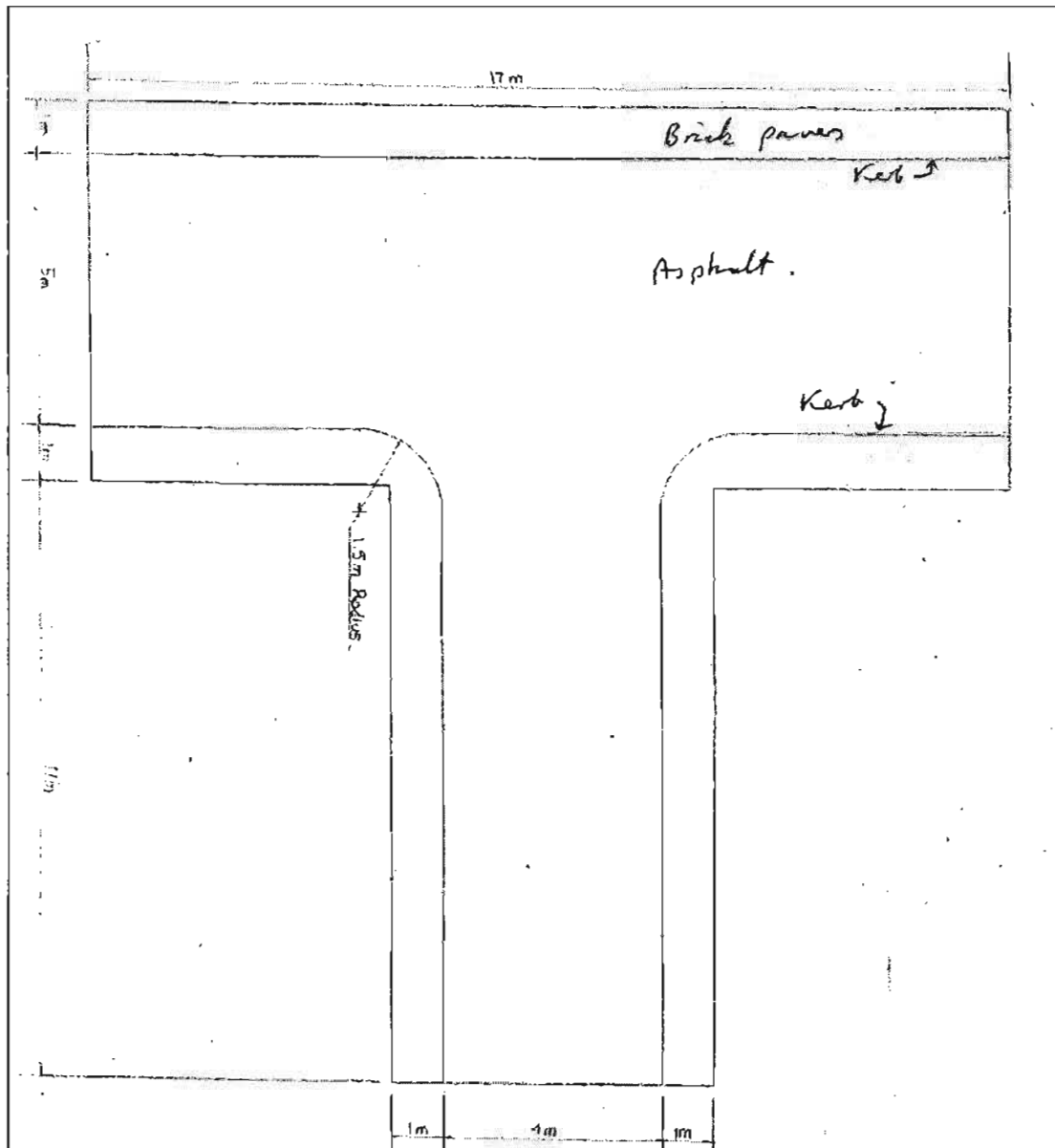
3. Calculate the surface area



4. Calculate the volume

5. Calculate the surface area

## Applied measuring exercise four

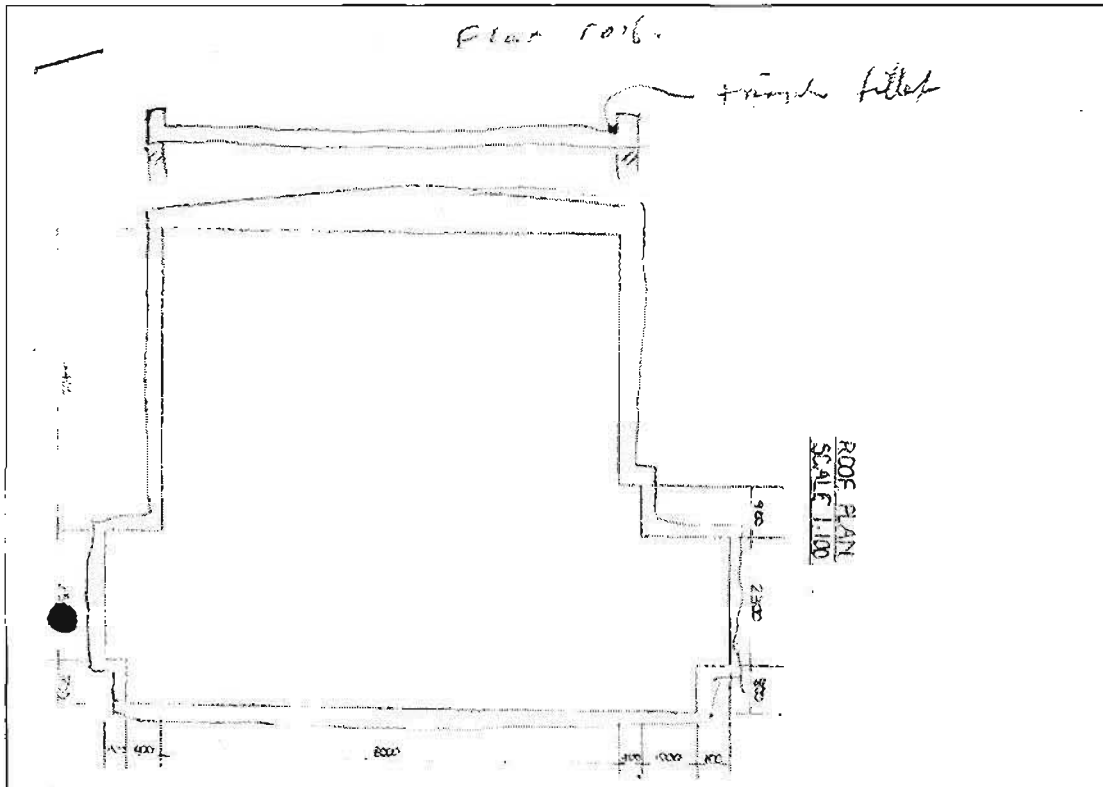


Calculate:

1. Length of outer perimeter
2. Length of straight kerb
3. Length of circular-on-plan kerb
4. Area of asphalt
5. Area of brick paving



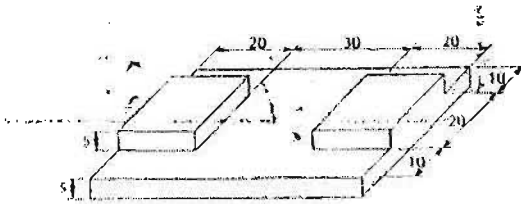
## Applied measuring exercise five



Calculate:

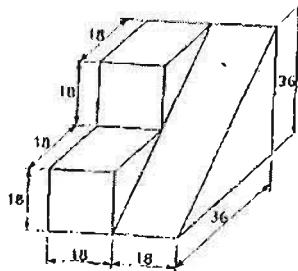
1. the area of the flat roof
2. the length of the triangular fillet

**Applied measuring exercise six**



Calculate:

1. the volume
2. the surface area



Calculate:

1. the volume
2. the surface area

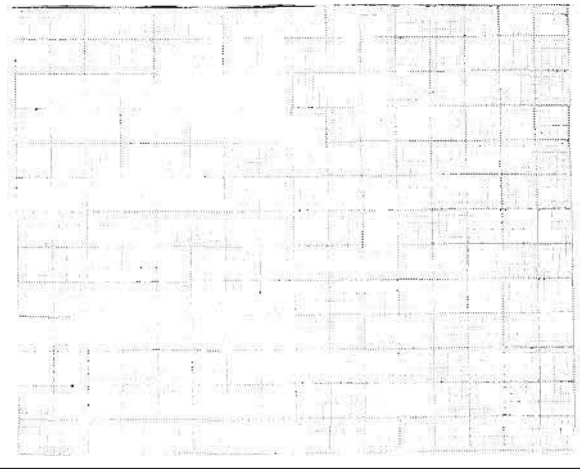
# Appendix F.

## Drawing interpretation exercise one

Draw the plan and side view of figure 5.38



Figure 5.38



Draw the plan, front and side views of figure 5.39

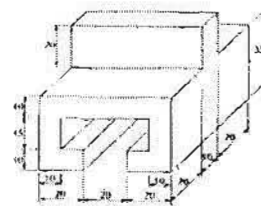
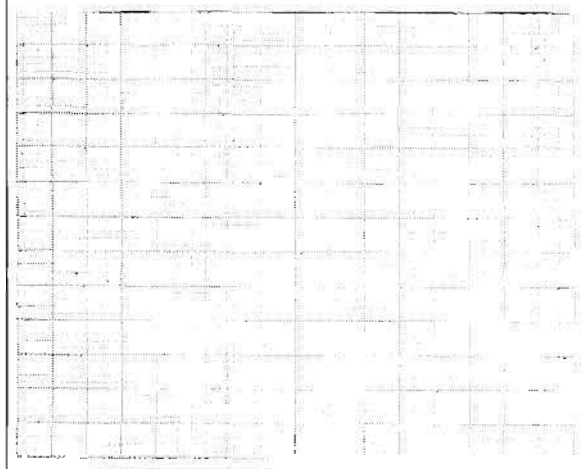
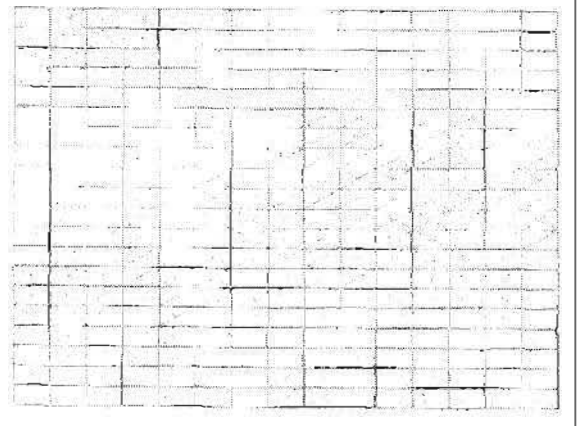
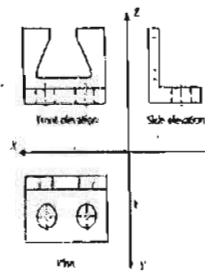


Figure 5.39



Draw an isometric view from the following plan and elevations



Draw the plan, and one elevation of figure 5.40

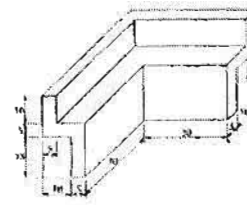
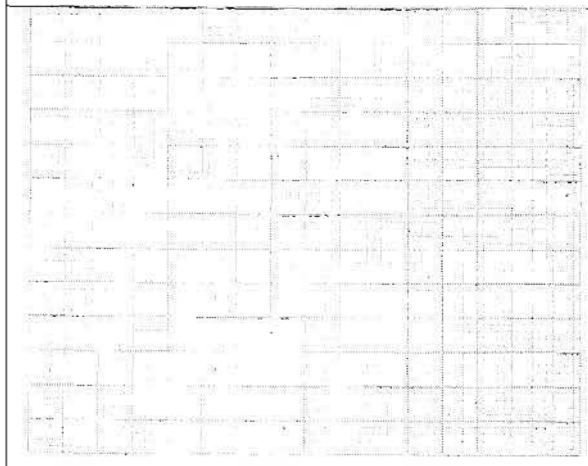
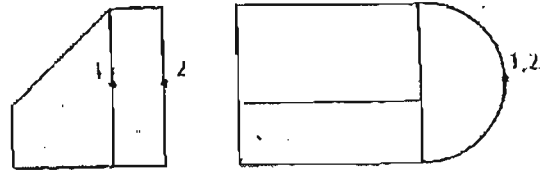


Figure 5.40

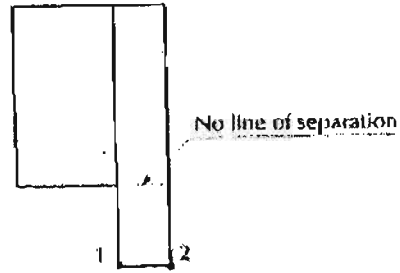


Draw an isometric view from the following plan and elevations

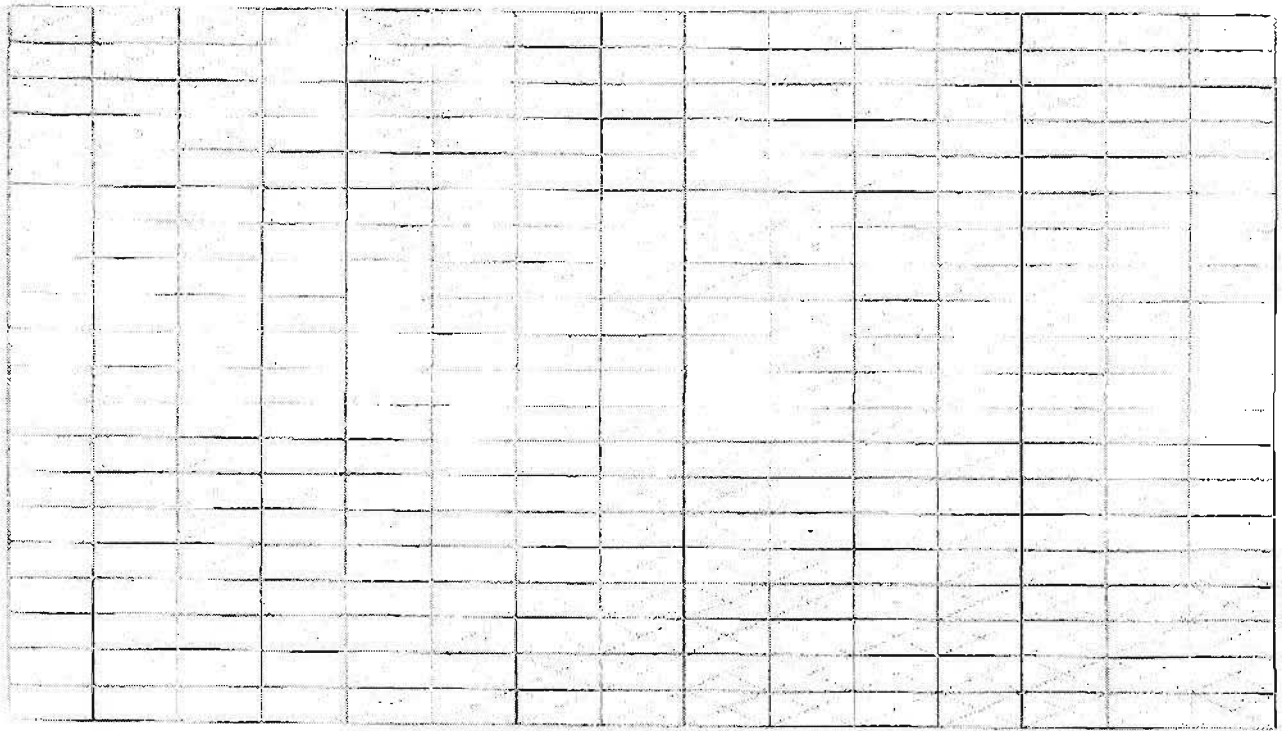


Front elevation

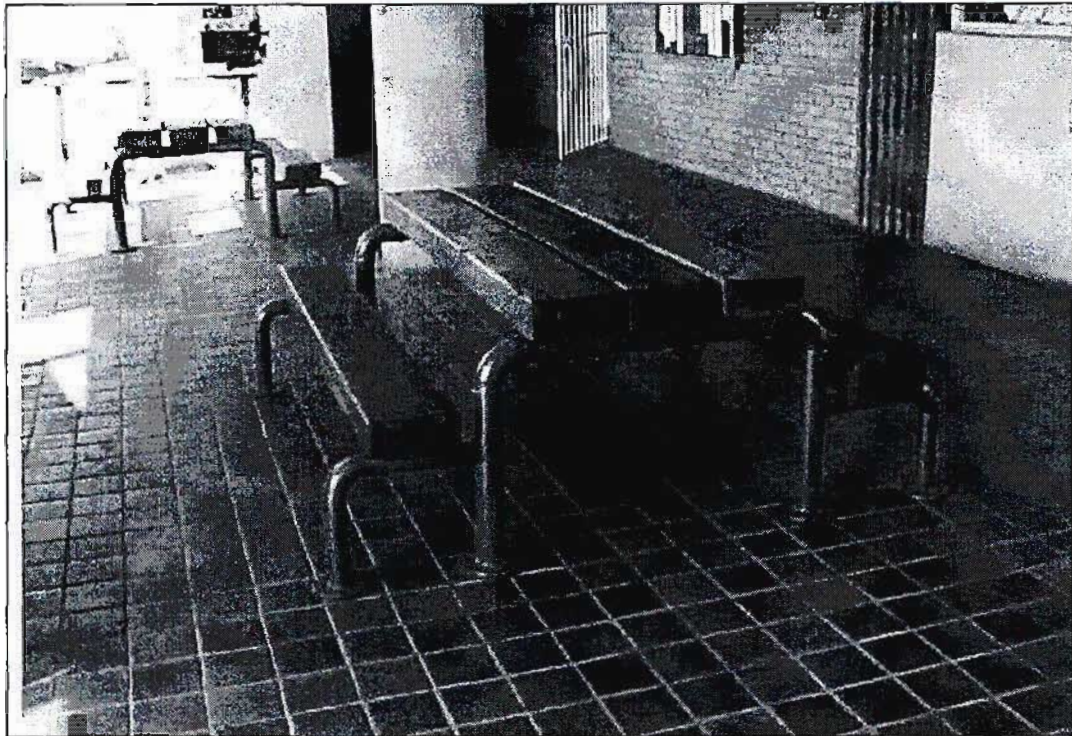
Side elevation



Plan



## Bench



Sketch a plan, side elevation, end elevation and cross section of this bench  
Show the arrows of cross section AA on the plan and one elevation

Plan	Side elevation
End elevation	Cross section A-A

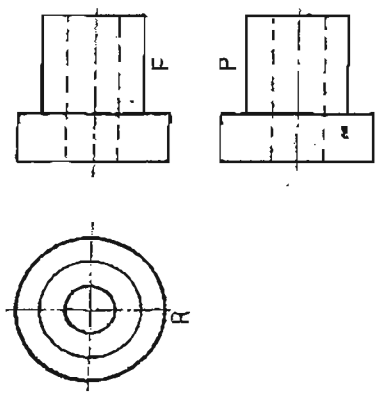
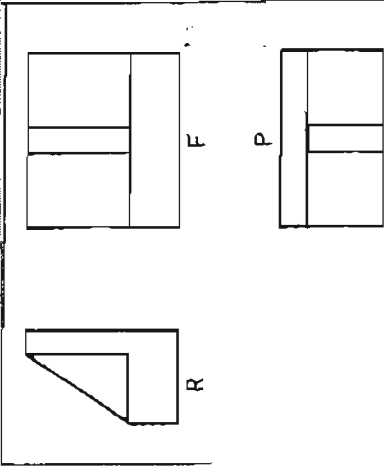
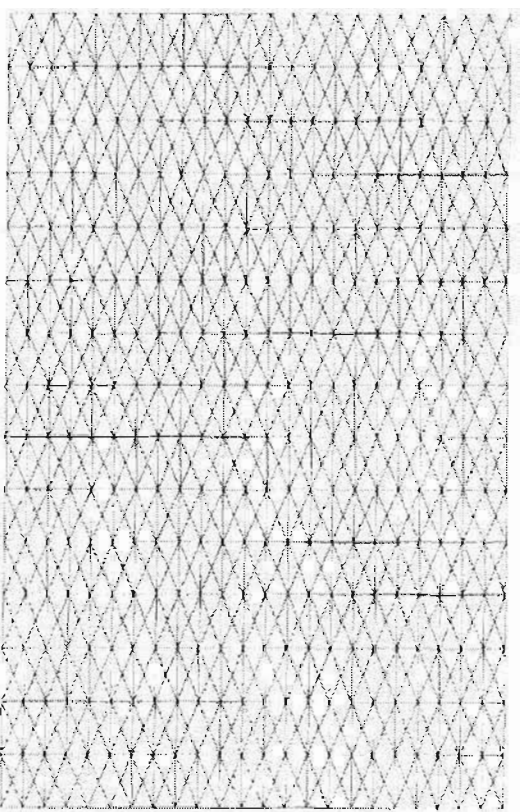
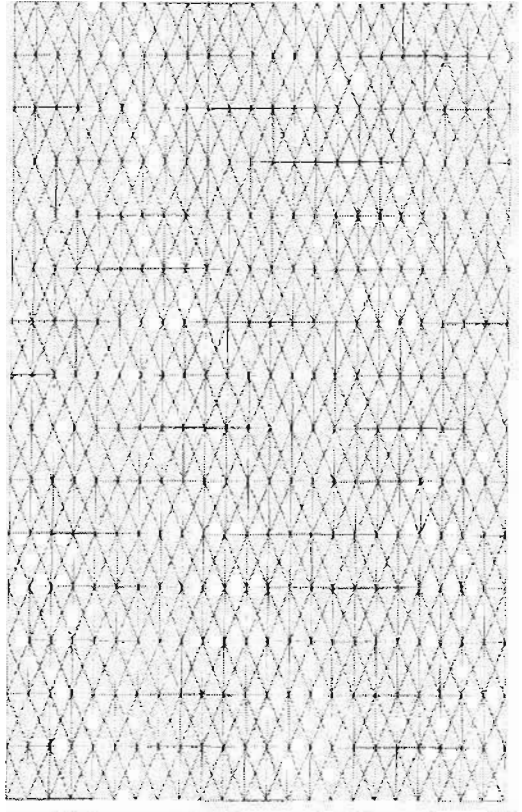
# Urinal



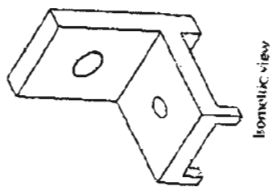
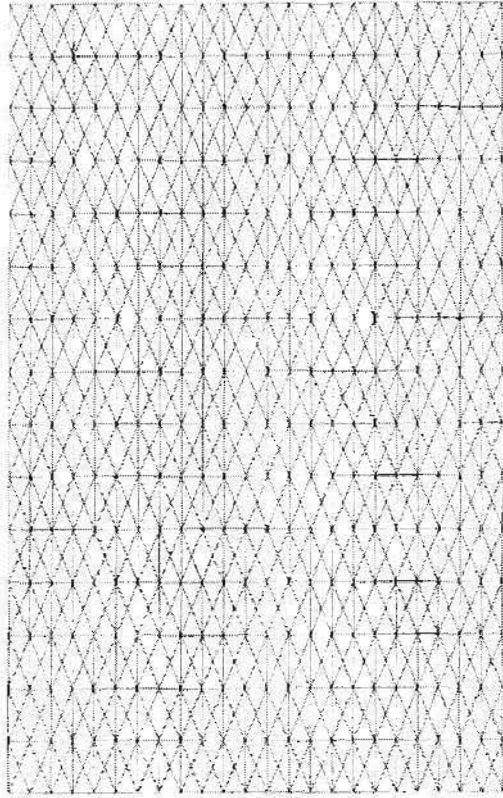
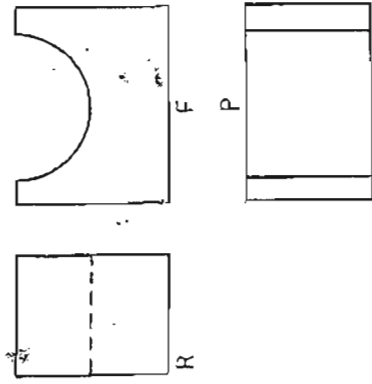
Sketch a plan, side elevation, front elevation and cross section of this urinal  
Show the arrows of cross section AA on the plan and one elevation

Plan	Side elevation
Front elevation	Cross section A-A

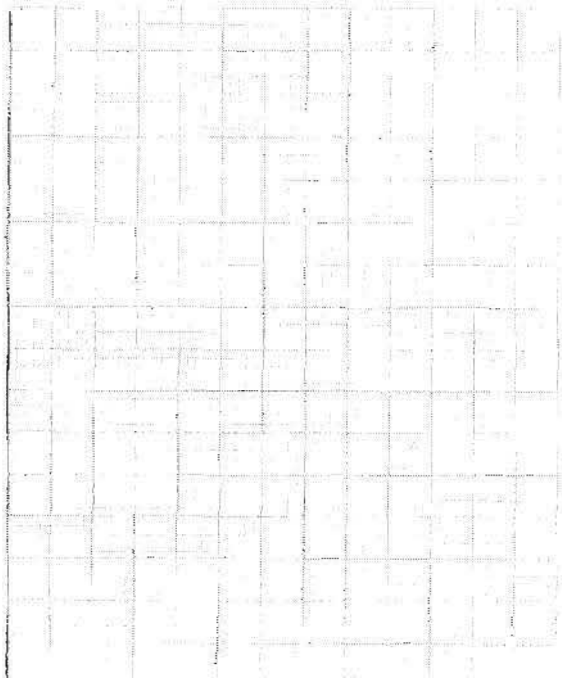
**Drawing interpretation exercise two**

<p>Draw an isometric view from the following plan and elevations</p> 	<p>Draw an isometric view from the following plan and elevations</p> 
	

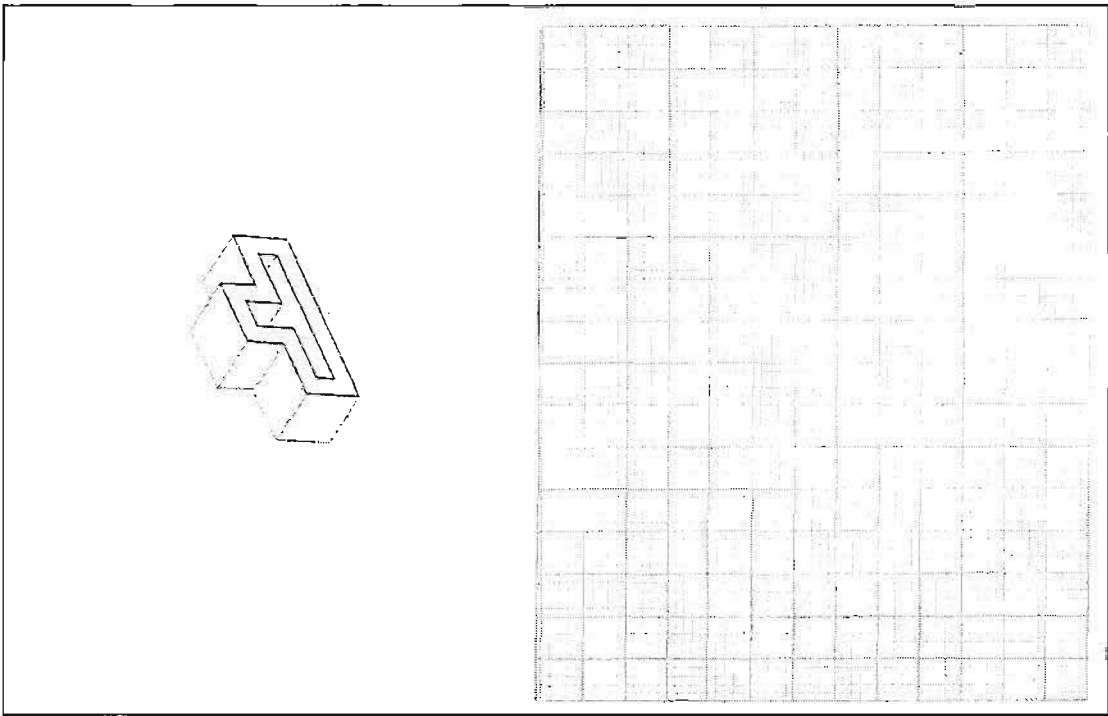
Draw an isometric view from the following plan and elevations



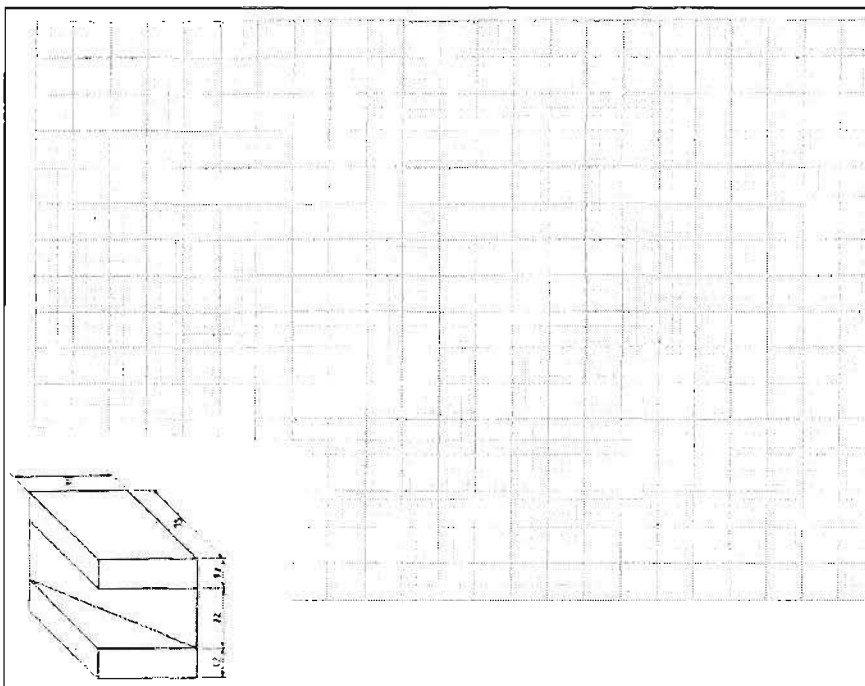
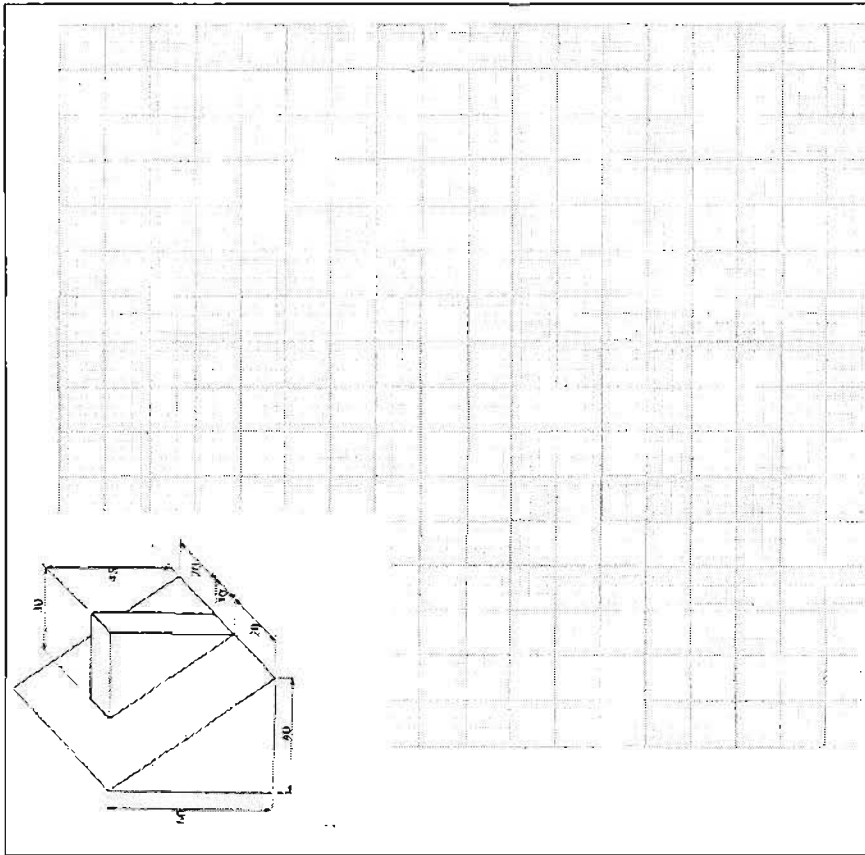
Isometric view

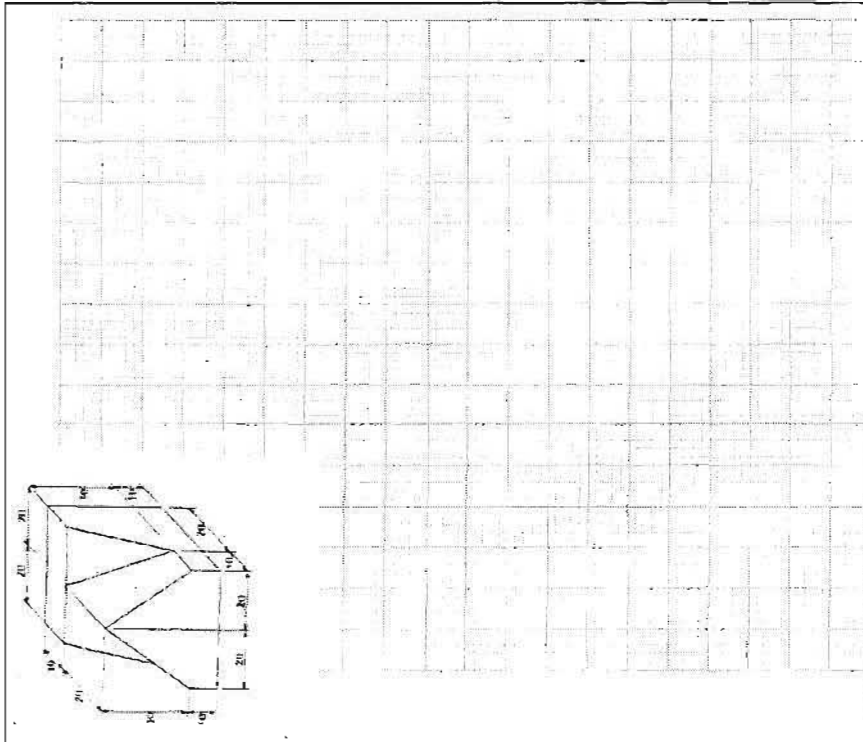






**Drawing interpretation exercise three**





### Drawing interpretation exercise four

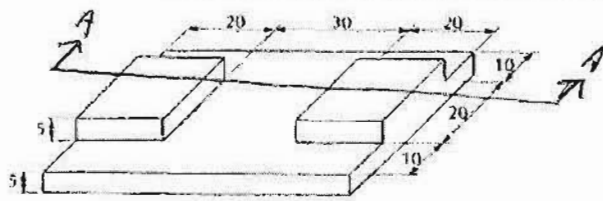
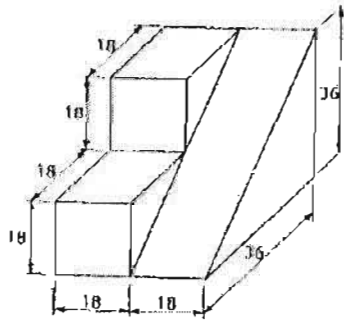


Figure 5.37

Draw:

1. Plan
2. End Elevation
3. Cross Section A-A



**Figure 5.51**

Draw:

1. Plan
2. End Elevation
3. Side Elevation

# Appendix G.

## Foundation detail

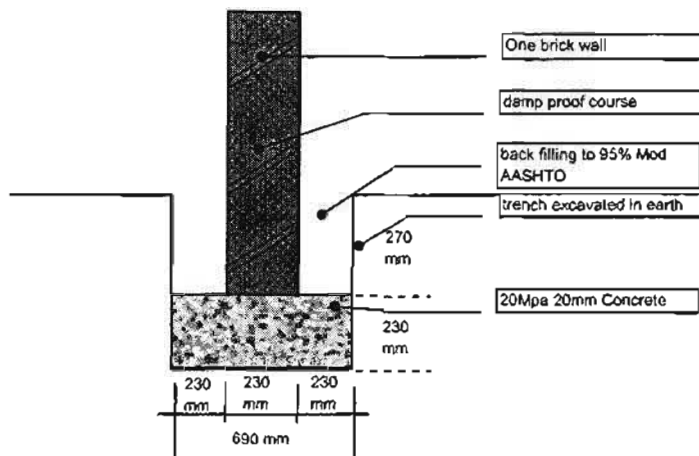
Draw a cross section of a footing to a one brick wall. Give typical dimensions and annotate your drawing.

Instructions

use the outline of the trench given below  
the drawing need not be to scale



### Answer



# Eaves Section

Draw a cross section of the eaves detail of a tiled roof, on timber trusses, on a one brick wall with plaster and paint both sides.

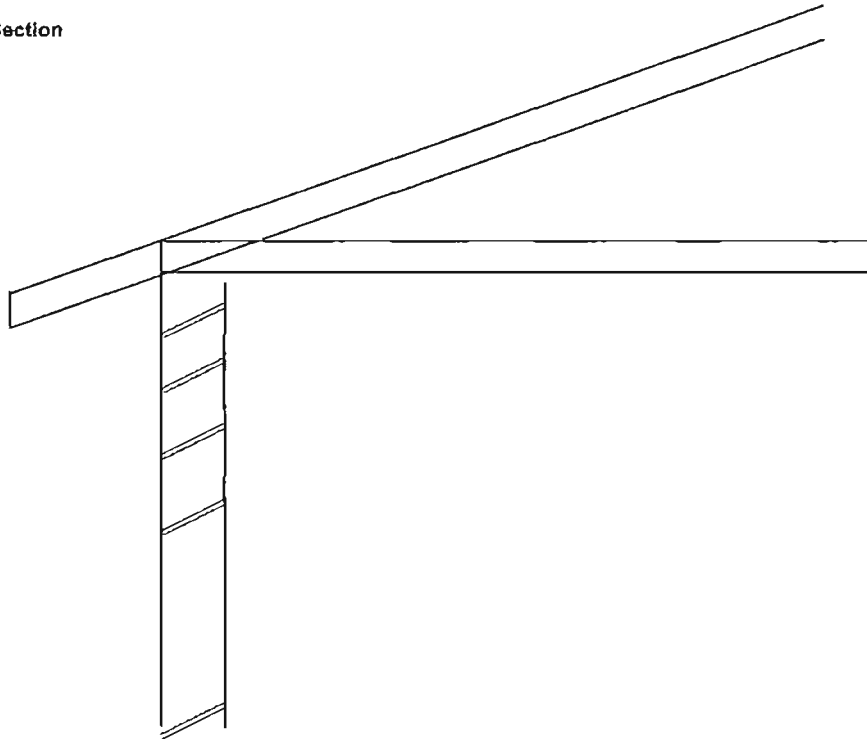
Anotate each component

instructions

draw within the outlines given below

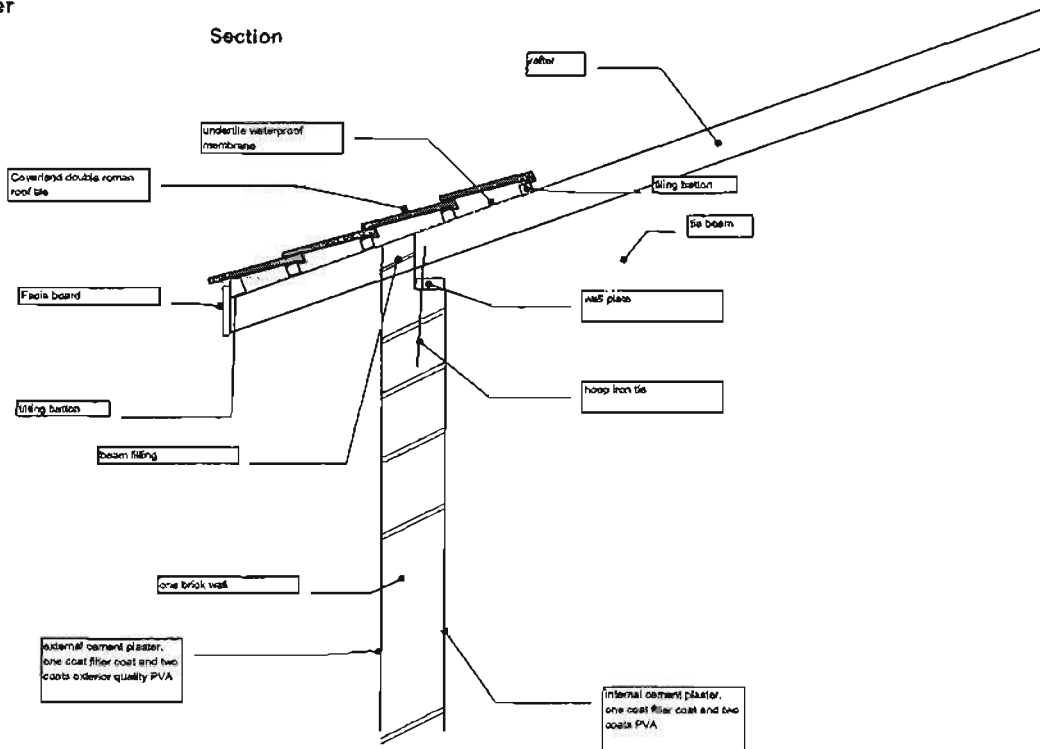
the drawing need not be to scale

Section



Answer

Section

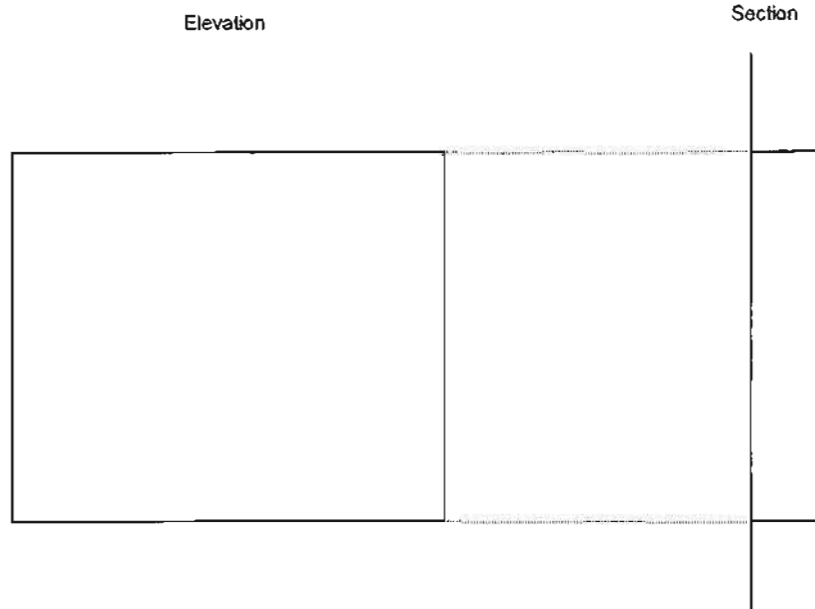


## Window and lintel section

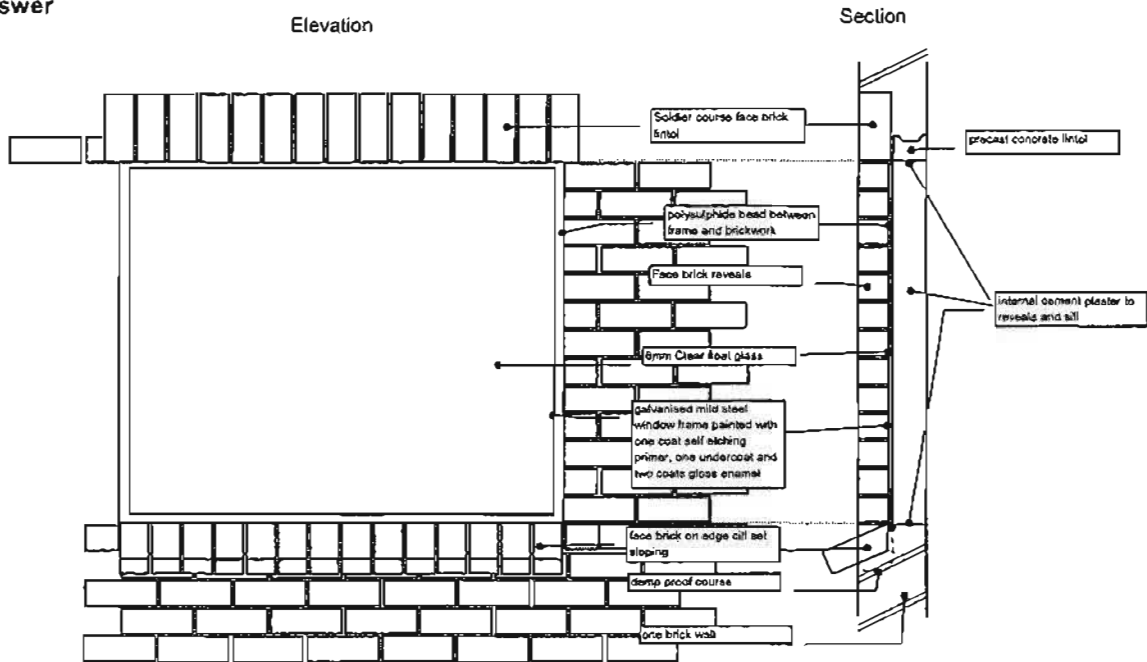
Draw a section and elevation of a steel window in a one brick wall, with facebrick externally and plaster and paint internally.  
Choose your own cill and lintel details. Annotate all details

### Instructions

draw within the outlines given below  
the drawing need not be to scale



### Answer

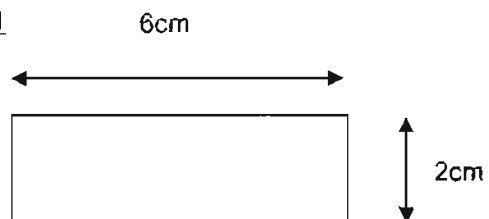




## Appendix H. Pre-test 2003 and 2004

### Rectangles, Parallelograms

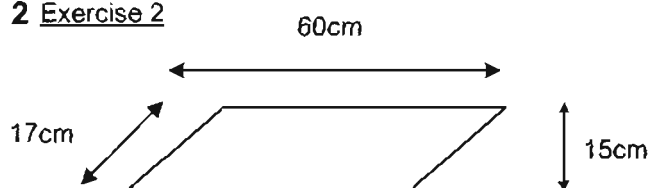
#### 1 Exercise 1



Give the :  
area \_\_\_\_\_  
perimeter \_\_\_\_\_  
of the above rectangle

a  
b

#### 2 Exercise 2

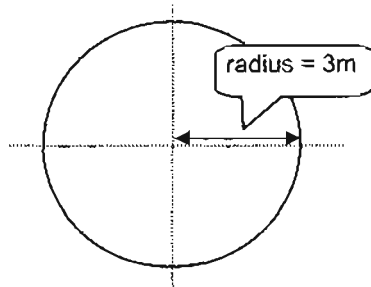


Give the :  
area \_\_\_\_\_  
perimeter \_\_\_\_\_  
of the above parallelogram

a  
b

## Circles

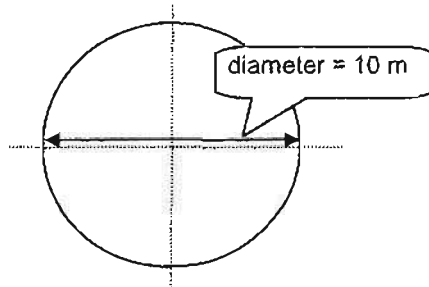
### 3 Exercise 6



For the above circle give the:

- a diameter \_\_\_\_\_
- b circumference \_\_\_\_\_
- c perimeter \_\_\_\_\_
- d area \_\_\_\_\_

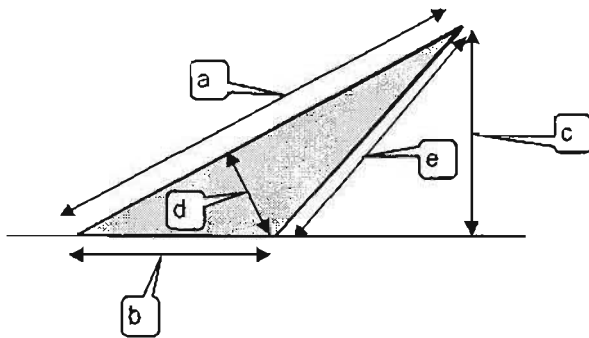
### 4 Exercise 8



For the above circle give the:

- a radius \_\_\_\_\_
- b circumference \_\_\_\_\_
- c area \_\_\_\_\_

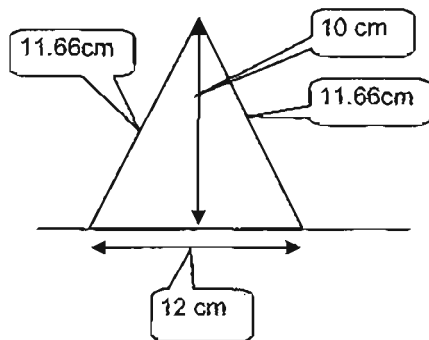
## Triangles



### 5 Exercise 11:

- a If the base of the triangle is **b**, what is its perpendicular height? \_\_\_\_\_
- b If the base of the triangle is **a**, what is its perpendicular height? \_\_\_\_\_

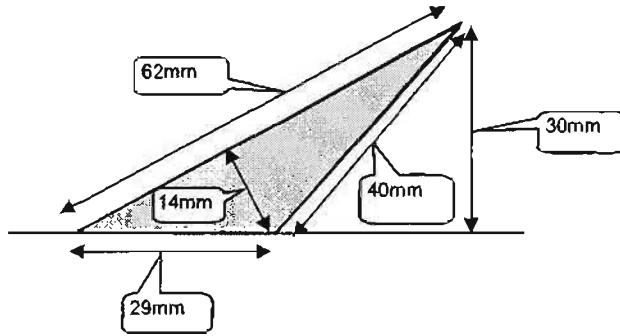
### 6 Exercise 12



For the above triangle give the :

- a Length of base \_\_\_\_\_
- b Perimeter \_\_\_\_\_
- c Perpendicular height \_\_\_\_\_
- d Area \_\_\_\_\_

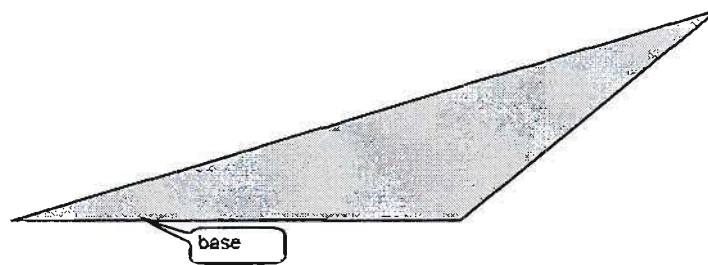
7 Exercise 13



For the above triangle and using the 29mm side as the base, give the following:

- a Perimeter \_\_\_\_\_
- b Perpendicular height \_\_\_\_\_
- c Area \_\_\_\_\_

8 Exercise 18:



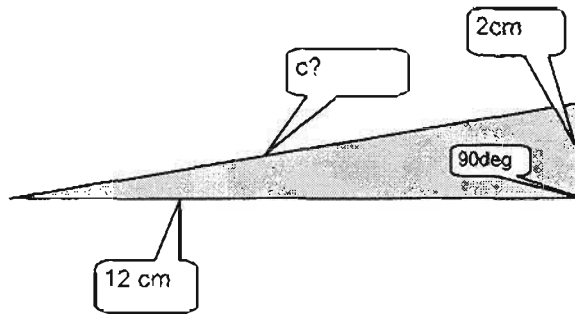
For the above triangle and using the side marked as the base, give the following:

(Do the measurements in millimetres)

- a Perimeter \_\_\_\_\_
- b Perpendicular height \_\_\_\_\_
- c Area \_\_\_\_\_

Pythagoras

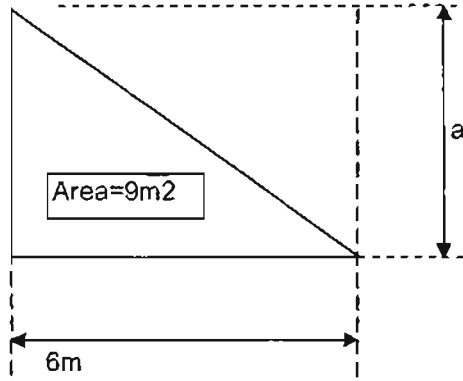
9 Exercise21



a For the above triangle give the length of c

\_\_\_\_\_

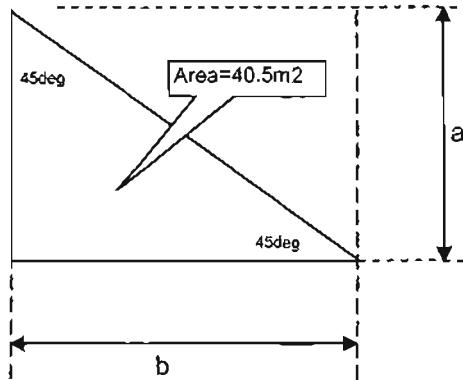
10



Calculate the:

- a Length of "a" \_\_\_\_\_
- b Length of hypotenuse \_\_\_\_\_

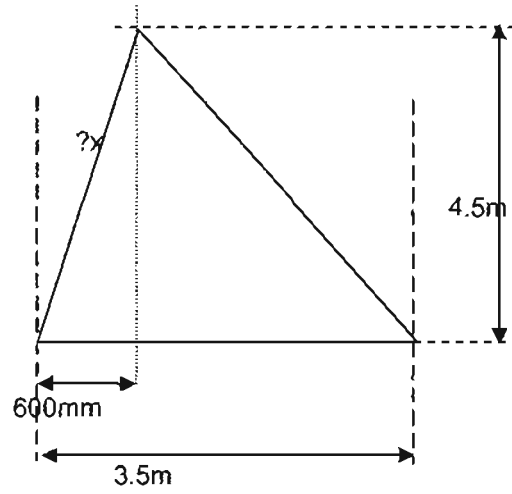
11



Calculate the:

- a Length of "a" \_\_\_\_\_
- b Length of hypotenuse \_\_\_\_\_
- c Perimeter \_\_\_\_\_

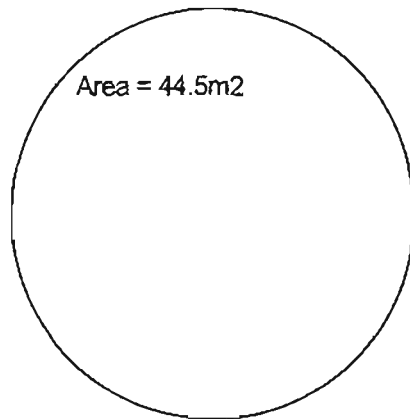
12



Calculate the:

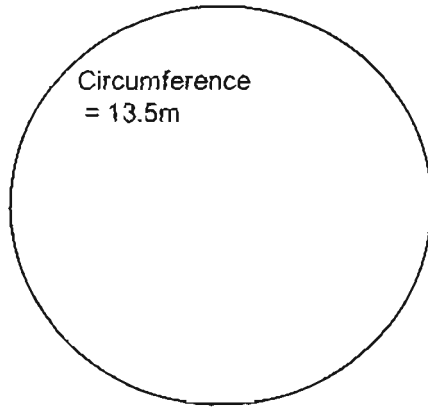
a Area \_\_\_\_\_

13



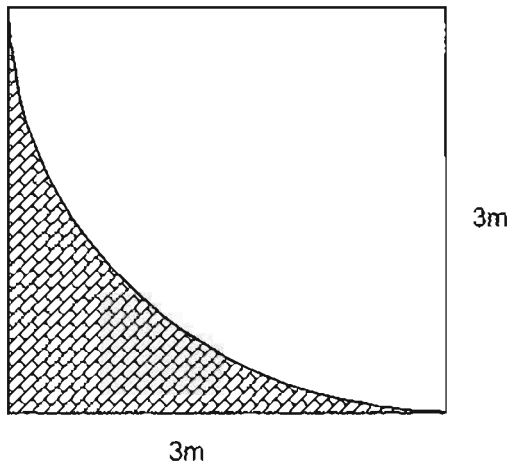
a What is the radius of this circle? \_\_\_\_\_

14



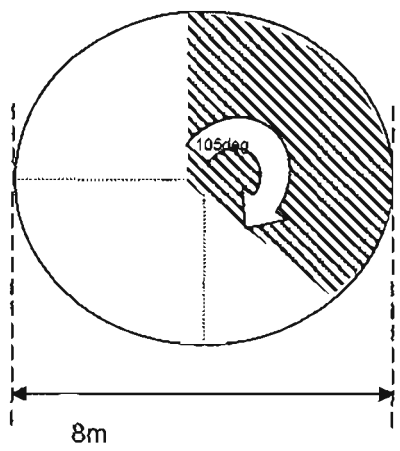
- a What is the diameter? \_\_\_\_\_  
b What is the area? \_\_\_\_\_

15



- Calculate the:
- a Radius \_\_\_\_\_  
b Area of the shaded portion \_\_\_\_\_  
c Perimeter of the shaded portion \_\_\_\_\_

16



- Calculate the:
- a Radius \_\_\_\_\_  
b Area of the shaded portion \_\_\_\_\_  
c Length of the arc of the shaded portion \_\_\_\_\_



Conversion from one unit to another:  
Fill in the missing measurements

**17 Length**

	mm	m	km
a		12.300	
b			1.33000
c	200		

**18 Weight**

	kg	ton
a	15.000	
b	0.750	
c		2.50000

**19 Areas**

	m <sup>2</sup>	hectare
a	3,000.000	
b		2.500

**20** Granite chips used in concrete costs R120 per m<sup>3</sup> delivered to your site.  
To impress on your workers the cost of the material you fill a five litre  
paint tin with granite chips. You calculate the cost of this amount of stone  
and explain to your workers the value of the stone that gets lost and  
scattered on site each day.

a How much is 5 lit of stone worth? \_\_\_\_\_  
\_\_\_\_\_

21 If the scale shown on a drawing is 1:500, how long is a fence that measures 53mm on the drawing?

\_\_\_\_\_

22 A standard door is 813mm wide.  
 You have a drawing that does not show the scale. It shows a standard doorway which measures about 16mm  
 What standard scale could the drawing be?

\_\_\_\_\_

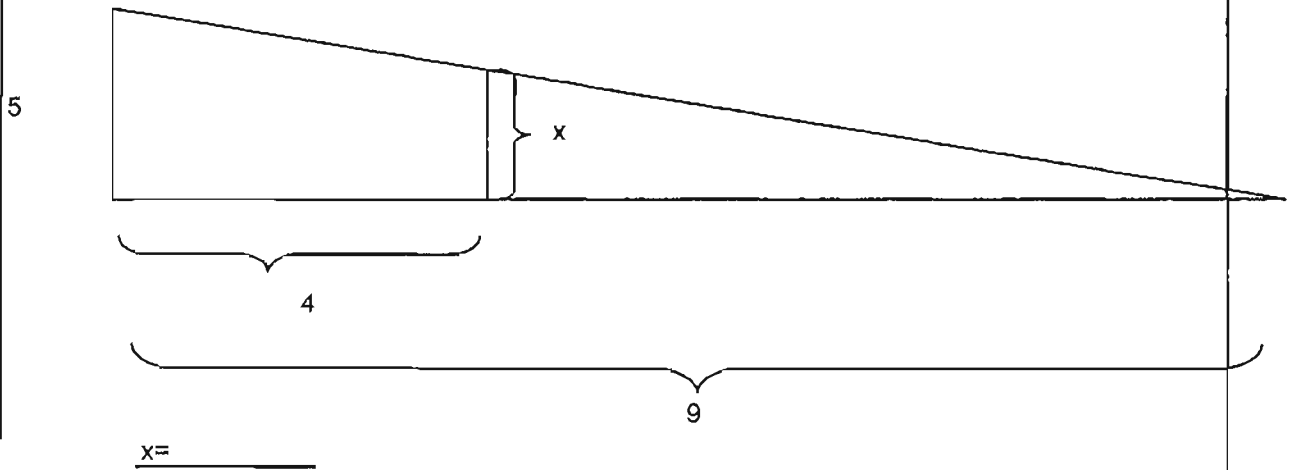
23 Fill in the missing information:

<u>Real life size</u>	<u>Scale</u>	<u>Measurement on the drawing in mm</u>	
	1:100	10mm	
6m	1:50		mm
100mm		100mm	
75mm		7.5mm	
360m	1:500		mm

a  
b  
c  
d  
e

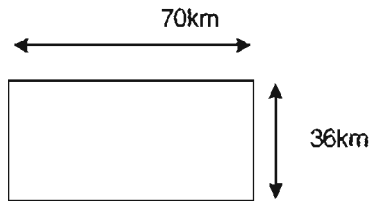
### Interpolation

24 Calculate "x" in each case



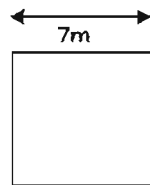
## Appendix I. Post test 2003 and 2004

### Rectangles



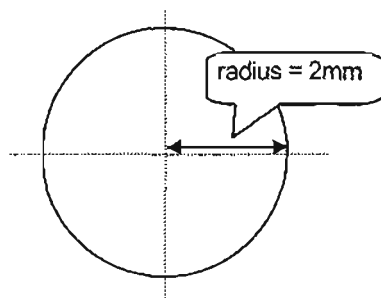
- 1 Give the :  
a area \_\_\_\_\_  
b perimeter \_\_\_\_\_  
of the above rectangle

The following image is a square:



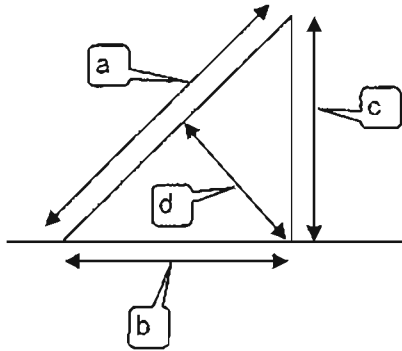
- 2 Give the :  
a area \_\_\_\_\_  
b perimeter \_\_\_\_\_  
of the above square

### Circles



- 3 For the above circle give the:  
a diameter \_\_\_\_\_  
b circumference \_\_\_\_\_  
c perimeter \_\_\_\_\_  
d area \_\_\_\_\_

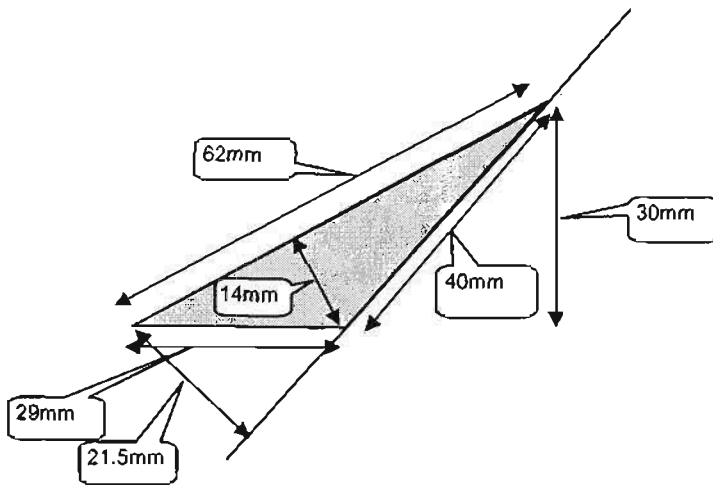
## Triangles



4

If the base of the triangle is  $a$ , what is its perpendicular height?

a



5

For the above triangle and using the 40mm side as the base, give the following:

a

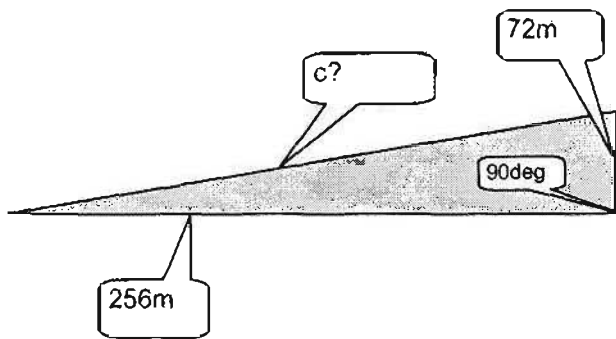
Perimeter

b

Area

\_\_\_\_\_

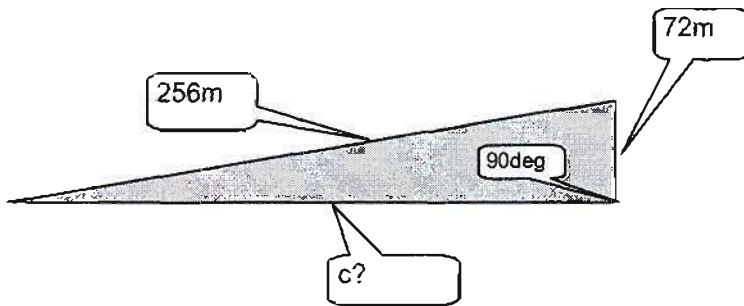
\_\_\_\_\_



6

a For the above triangle give the length of c

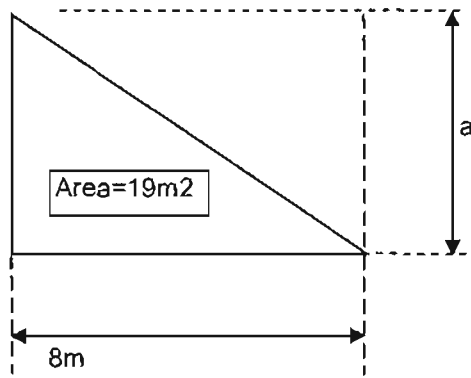
\_\_\_\_\_



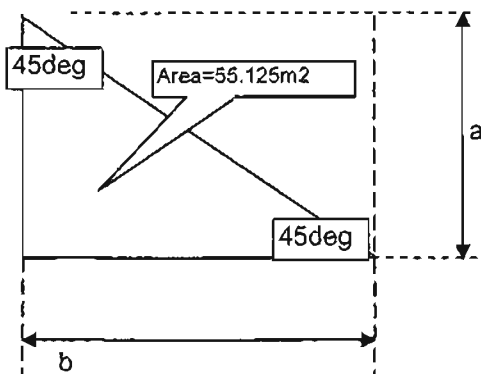
7

a For the above triangle give the length of c

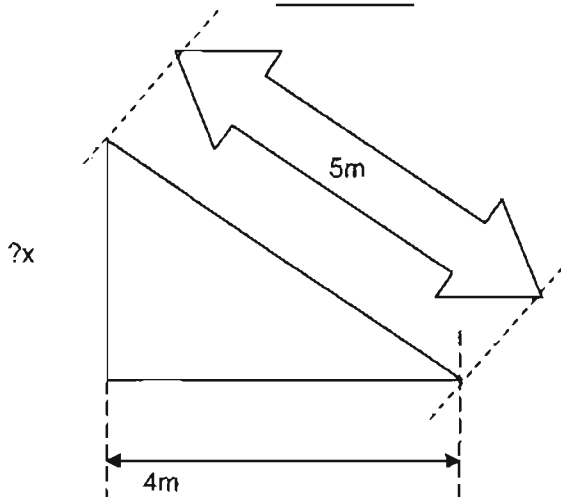
\_\_\_\_\_



- 8 Calculate the:
- a Length of "a" \_\_\_\_\_
- b Length of hypotenuse \_\_\_\_\_

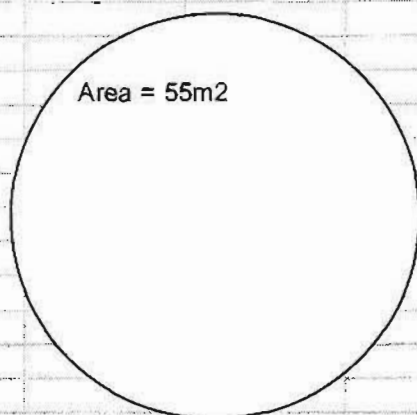


- 9 Calculate the:
- a Length of "a" \_\_\_\_\_
- b Length of hypotenuse \_\_\_\_\_
- c Perimeter \_\_\_\_\_



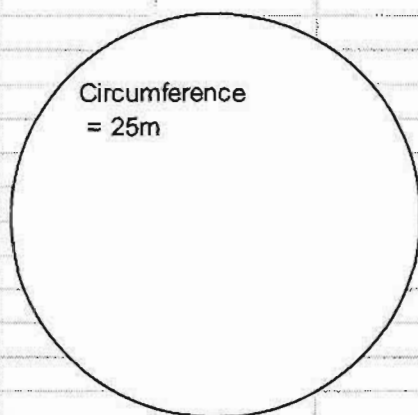
- 10 Calculate the:
- a Length of side "x" \_\_\_\_\_
- b Area \_\_\_\_\_

## Circles



11

a What is the radius of this circle? \_\_\_\_\_

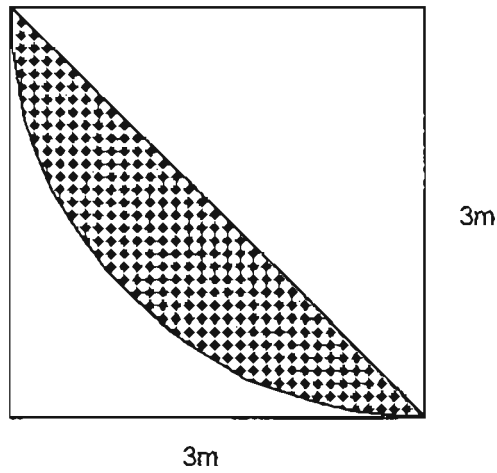


12

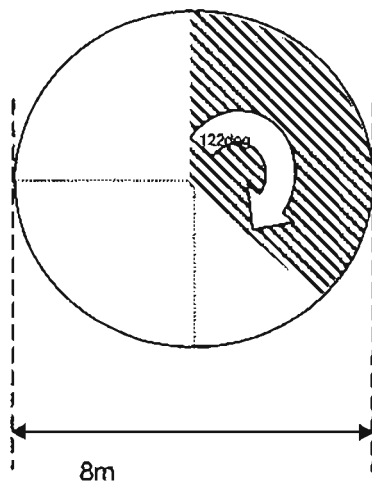
a What is the diameter? \_\_\_\_\_

b What is the area? \_\_\_\_\_

**Parts of circles**

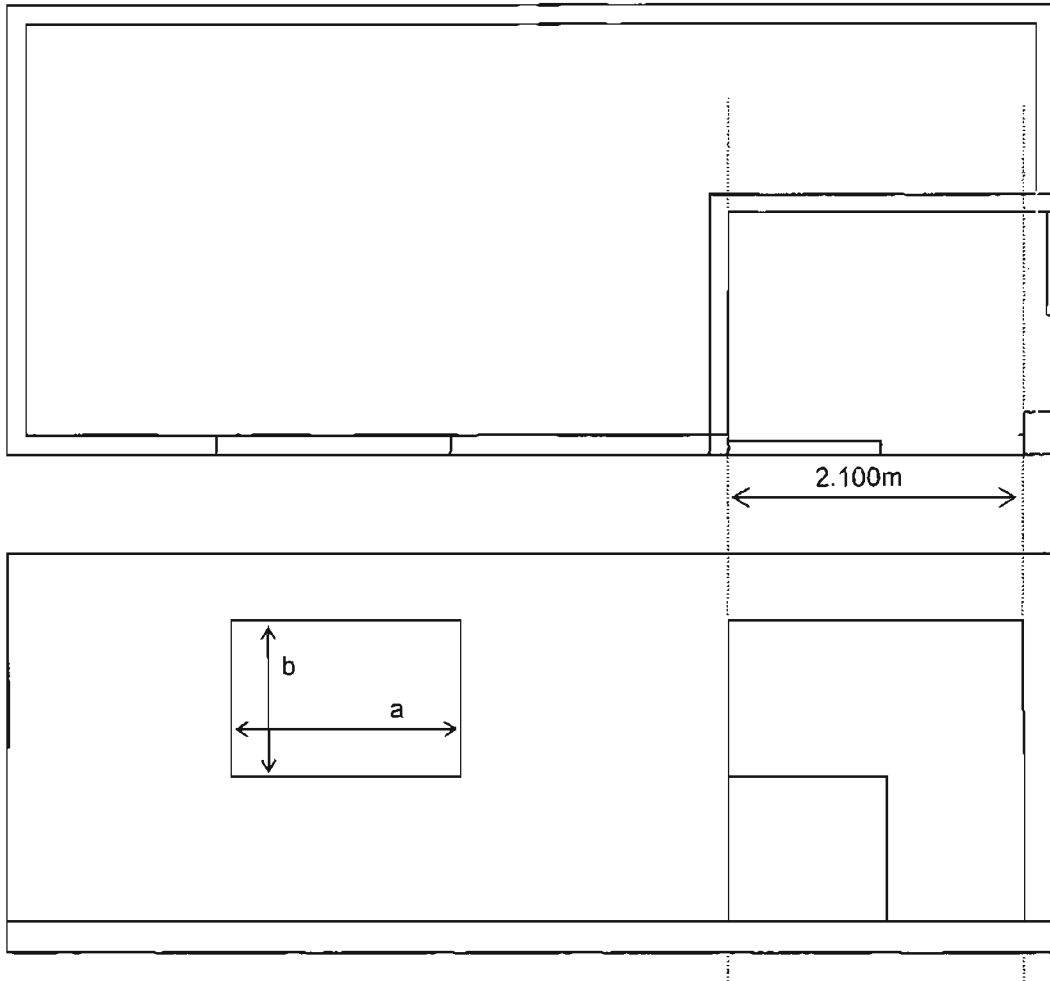


- 13 Calculate the:
- a Area of the shaded portion \_\_\_\_\_
  - b Perimeter of the shaded portion \_\_\_\_\_



- 14 Calculate the:
- a Area of the shaded portion \_\_\_\_\_
  - b Circumference of the shaded portion \_\_\_\_\_





- 15 The attached drawing refers:  
 a What scale is the drawing?  
 b What is the length of "a"  
 c What is the length of "b"

- 16 A standard door is 813mm wide.  
 You have a drawing that does not show the scale. It shows a standard doorway which measures about 32mm  
 a What could the scale of the drawing be?

17 Fill in the missing information:

	<u>Real life size</u>	<u>Scale</u>	<u>Measurement on the drawing in mm</u>
a	<input type="text"/>	1:25	12mm
b	6m	1:75	<input type="text"/> mm
c	100mm	<input type="text"/>	200mm
d	750mm	<input type="text"/>	7.5mm
e	32m	1:50	<input type="text"/> mm

**Units**

18 Length

	mm	m	km
a		0.660	
b	1230.000		
c			1.400

19 Weight

	g	kg	ton
a	1230.000		
b			1.400
c	250.000		

19 Areas

	m <sup>2</sup>	hectare
a	750.000	
b		2.500
c		1.400

20 Volume

	ml	liter	m <sup>3</sup>
a		0.650	
b			1.500

21 You notice on an invoice that a 5 lit tin of Plascon "Wall n all" costs R165.00

How much does a teaspoon ful of this paint cost?  
(a teaspoon is 5 ml)

(ml means milli-litre)

a \_\_\_\_\_

22 A typical box of photostat paper has the following information on it:  
Contents 5 reams (500 sheets per ream)  
Size A4 297 x 210 mm  
Weight 80 gm per m<sup>2</sup>

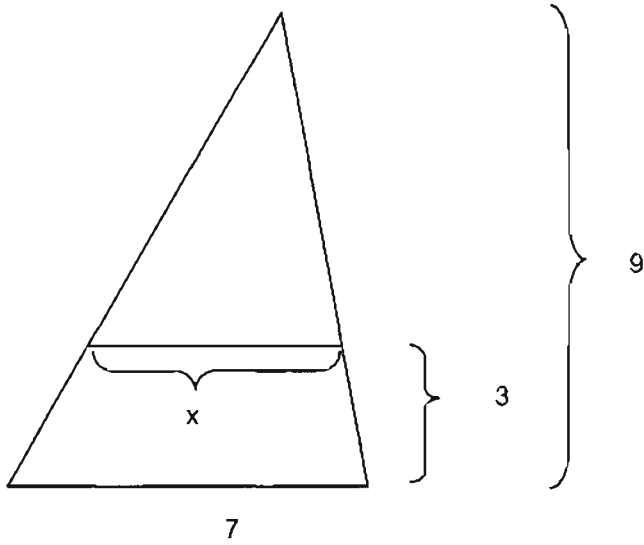
How many m<sup>2</sup> of paper does the box contain?

a \_\_\_\_\_ m<sup>2</sup>

How many kg's does the paper weigh? (Excluding the box and wrapping)

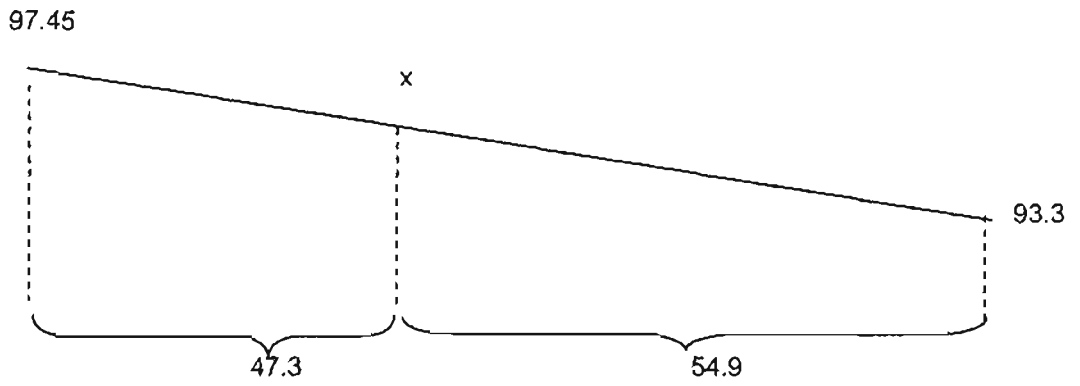
b \_\_\_\_\_ kg

23



a Calculate the length of "x" \_\_\_\_\_

24



a Calculate the level at point 'x' \_\_\_\_\_



**Post-fest 2003**

Full

Q Type	Question	Bloom	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	
1 a	Simple	Rect:area	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
b	Simple	Rect:peri	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
2 a	Simple	Square:area	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
b	Simple	Square:peri	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
3 a	Termin.	Circ:dia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
b	Simple	Circ:circum	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
c	Termin.	Circ:peri	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
d	Simple	Circ:area	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
4 a	Termin.	Trig:periph	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
5 a	Simple	Trig:area	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
b	Simple	Trig:peri	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
6 a	Simple	Trig:Pyth	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
7 a	Manip.	Trig:Pyth	6	0	6	3	6	0	6	6	6	6	6	6	6	6	6	6	
8 a	Manip.	Trig:	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
b	Simple	Trig:Pyth	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
9 a	Manip.	Trig:Pyth	6	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
b	Simple	Trig:peri	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
c	Manip.	Trig:	6	0	3	6	6	0	3	6	0	6	0	6	6	6	6	3	
10 a	Manip.	Trig:area	2	0	1	2	2	0	2	2	0	2	0	2	2	2	2	1	
b	Simple	Circ:rad	6	0	6	6	6	3	6	6	6	6	6	6	6	6	6	6	
11 a	Manip.	Circ:dia	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
12 a	Manip.	Circ:area	2	0	2	2	2	0	1	2	2	2	2	2	2	2	2	2	
b	Simple	Circ:area	6	6	0	0	0	6	6	6	6	6	6	6	6	6	6	6	
13 a	Applied C	1/4circ	6	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	
b	Applied C	1/4circ	6	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	
14 a	Two Lev.	part circ	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
b	Applied C	part circ	6	0	6	3	0	0	6	6	6	6	6	6	6	6	6	6	
15 a	Conv Scale	comprehensi:apply	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	
b	Conv Scale	comprehensi:apply	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
c	Conv Scale	comprehensi:apply	2	0	2	0	2	2	2	2	2	2	2	2	2	2	2	2	
16 a	Conv Scale	comprehensi:apply	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
17 a	Conv Scale	Conv Scale	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
b	Conv Scale	Conv Scale	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	
c	Conv Scale	Conv Scale	2	0	2	0	0	0	2	0	2	0	0	2	2	2	2	0	
d	Conv Scale	Conv Scale	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
e	Conv Scale	Conv Scale	2	0	2	0	0	2	0	2	0	2	0	2	2	2	2	0	
18 a	Conv Unit	Conv Unit	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
b	Conv Unit	Conv Unit	4	4	4	3	4	4	2	4	4	4	4	2	4	4	4	4	
c	Conv Unit	Conv Unit	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
19 a	Conv Unit	Conv Unit	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
b	Conv Unit	Conv Unit	4	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	
c	Conv Unit	Conv Unit	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
19 a	Conv Unit	Conv Unit	4	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	
b	Conv Unit	Conv Unit	4	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	
c	Conv Unit	Conv Unit	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
20 a	Conv Unit	Conv Unit	4	0	4	0	4	4	4	4	4	4	4	4	4	4	4	0	
b	Conv Unit	Conv Unit	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
21 a	Whole C.	comprehensi:analyse	10	10	0	10	10	0	10	10	0	10	0	10	10	10	10	10	
b	Whole C.	comprehensi:analyse	10	0	0	10	10	0	10	10	0	10	0	10	10	10	10	0	
23 a	Ratio	similare trig	6	0	0	6	6	0	6	0	6	0	6	0	6	0	6	0	
24 a	Whole C.	comprehensi:analyse	10	0	0	10	0	0	10	10	0	10	0	10	10	10	10	0	
		Mark	197	82	129	157	151	85	173	161	131	149	120	68	91	189	189	93	143
		Percent	42%	65%	80%	77%	43%	88%	82%	66%	76%	61%	35%	46%	96%	96%	47%	73%	

# Appendix K. Pre- and post-test results 2004

Pre-test 2004		Full Marks	S1	S2	S3	S4	S5	S6	S7	S8
Q Type	Question Bloom									
1 a	Simple Rect:area apply	2	2	2	2	2	2	2	2	0
b	Simple Rect:peri apply	2	2	2	2	2	2	0	2	2
2 a	Simple P:gram:area apply	2	0	2	0	2	2	0	2	0
b	Simple P:gram:peri apply	2	0	2	2	2	0	0	2	2
3 a	Simple Circ:dia remember	1	1	1	1	1	1	0	1	1
b	Simple Circ:circum remember	1	0	0	0	1	0	0	1	1
c	Simple Circ:peri apply	2	0	0	0	2	0	0	2	2
d	Simple Circ:area apply	2	2	0	2	2	2	0	2	2
4 a	Simple Circ:radius remember	1	1	0	0	2	2	1	0	1
b	Simple Circ:area apply	2	2	0	2	2	2	2	2	2
c	Simple Trig:periph understand	1	1	1	0	1	1	1	1	0
b	Simple Trig:periph understand	1	1	1	0	1	1	1	1	1
6 a	Simple Trig:base remember	1	1	1	1	1	1	1	1	1
b	Simple Trig:peri apply	2	2	2	2	2	0	0	2	2
c	Simple Trig:periph understand	1	1	1	1	1	1	1	1	1
d	Simple Trig:area apply	2	2	2	2	2	2	2	2	2
7 a	Simple Trig:peri apply	2	2	2	2	2	2	0	2	2
b	Simple Trig:periph understand	1	1	1	0	1	0	1	1	0
c	Simple Trig:area apply	2	0	2	0	2	0	2	2	0
b	Simple Trig:periph understand	2	0	2	0	2	1	2	2	0
c	Simple Trig:area apply	2	0	2	0	2	0	2	2	0
9 a	Simple Trig:Pyth apply	2	2	2	2	2	2	2	2	2
10 a	Manip. Trig: create	6	6	6	0	6	6	6	6	6
b	Manip. Trig:Pyth apply	2	0	2	0	2	2	2	2	2
11 a	Manip. Trig: create	6	0	6	0	6	0	6	0	6
b	Simple Trig:Pyth apply	2	0	2	0	2	2	0	2	2
c	Simple Trig:peri apply	2	0	2	0	2	2	0	2	2
12 a	Simple Trig:area apply	2	2	2	2	2	0	2	2	2
b	Two Lev. Trig:Pyth apply	4	4	4	0	4	4	4	4	4
13 a	Manip. Circ:rad create	6	0	0	6	6	6	0	6	0
14 a	Manip. Circ:dia create	6	0	0	0	6	6	6	0	0
b	Simple Circ:area create	2	0	0	0	2	0	2	0	0
15 a	Simple Circ:rad understand	2	0	0	0	0	2	0	2	2
b	Applied C 1/4circ create	6	0	0	0	0	6	0	6	6
c	Applied C 1/4circ create	6	0	0	0	0	6	0	0	6
16 a	Simple Circ:rad remember	1	0	1	0	1	1	0	1	1
b	Two Lev. part circ create	4	0	0	0	0	4	0	0	0
c	Two Lev. part circ create	4	0	0	0	0	0	0	0	0
17 a	Conv Unit Conv Unit apply	4	2	4	4	4	4	0	4	0
b	Conv Unit Conv Unit apply	4	2	4	0	4	2	0	4	4
c	Conv Unit Conv Unit apply	4	2	4	4	4	0	0	4	4
18 a	Conv Unit Conv Unit apply	2	0	2	2	2	2	0	2	0
b	Conv Unit Conv Unit apply	2	0	2	2	2	2	0	2	2
c	Conv Unit Conv Unit apply	2	0	2	2	2	2	0	2	2
19 a	Conv Unit Conv Unit apply	2	0	0	0	2	2	0	0	0
b	Conv Unit Conv Unit apply	2	0	0	0	2	2	0	0	2
20 a	Whole C. comprehens analyse	10	0	10	0	10	0	0	10	0
21 a	Conv Scale comprehend apply	2	0	0	0	2	0	0	0	0
22 a	Conv Scale comprehend apply	2	0	2	0	2	0	0	0	0
23 a	Conv Scale Conv Scale apply	2	2	2	0	0	0	0	0	2
b	Conv Scale Conv Scale apply	2	0	2	0	2	0	0	0	0
c	Conv Scale Conv Scale apply	2	0	2	2	2	0	0	2	2
d	Conv Scale Conv Scale apply	2	2	2	0	2	0	0	0	2
e	Conv Scale Conv Scale apply	2	0	0	0	2	0	0	0	0
24 a	Applied C. similare trig apply	6	0	0	0	0	6	0	6	0
27 a	Cons. Name Cons. Name remember	8	0	5	4	6	8	0	6	0
28 a	Cons. Name Cons. Name remember	7	3	5	4	7	7	0	3	0
<b>Mark</b>		<b>168</b>	<b>50</b>	<b>104</b>	<b>53</b>	<b>142</b>	<b>122</b>	<b>41</b>	<b>132</b>	<b>85</b>
<b>Percent</b>			<b>30%</b>	<b>62%</b>	<b>32%</b>	<b>85%</b>	<b>73%</b>	<b>24%</b>	<b>79%</b>	<b>51%</b>

<b>Post-test 2004</b>				<b>Full</b>									
	<b>Q Type</b>	<b>Question</b>	<b>Bloom</b>	<b>Marks</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>	<b>S5</b>	<b>S6</b>	<b>S7</b>	<b>S8</b>	
1 a	Simple	Rect:area	apply	2	2	2	2	2	2	2	2	2	
b	Simple	Rect:peri	apply	2	2	2	2	2	2	2	2	2	
2 a	Simple	Square:area	apply	2	2	2	2	2	2	2	2	2	
b	Simple	Square:peri	apply	2	2	2	2	2	2	2	2	2	
3 a	Simple	Circ:dia	remember	1	1	1	1	1	1	1	1	1	
b	Simple	Circ:circum	remember	2	2	2	2	2	2	2	2	2	
c	Simple	Circ:peri	apply	1	1	1	1	1	1	1	1	1	
d	Simple	Circ:area	apply	2	2	2	2	2	2	2	2	0	
4 a	Simple	Trig:perpht	understand	1	1	1	1	1	1	1	1	1	
5 a	Simple	Trig:area	apply	2	2	2	0	2	2	2	0	2	
b	Simple	Trig:peri	apply	2	0	0	0	2	0	0	2	0	
6 a	Simple	Trig:Pyth	apply	2	2	2	2	2	0	0	2	2	
7 a	Manip.	Trig:Pyth	apply	6	0	6	6	6	0	0	6	0	
8 a	Manip.	Trig:	create	6	6	6	6	6	6	6	0	6	
b	Simple	Trig:Pyth	apply	2	2	2	0	2	2	2	0	0	
9 a	Manip.	Trig:	create	6	0	6	0	6	6	0	6	6	
b	Simple	Trig:Pyth	apply	2	0	2	0	2	2	0	2	2	
c	Simple	Trig:peri	apply	2	0	2	0	2	2	0	2	2	
10 a	Manip.	Trig:	create	6	6	6	6	6	6	6	6	6	
b	Simple	Trig:area	apply	2	2	2	2	2	2	2	0	2	
11 a	Manip.	Circ:rad	create	6	6	6	6	6	6	6	6	6	
12 a	Manip.	Circ:dia	create	6	6	6	6	6	6	6	6	6	
b	Simple	Circ:area	create	2	2	2	0	2	2	2	2	2	
13 a	Applied C	1/4circ	create	6	0	6	0	6	6	0	6	0	
b	Applied C	1/4circ	create	6	0	0	0	6	6	0	6	0	
14 a	Applied C	part circ	create	4	0	4	0	4	4	0	4	4	
b	Applied C	part circ	create	6	0	6	0	6	6	0	6	6	
15 a	Conv Scale	comprehens	apply	2	0	2	0	2	0	0	0	0	
b	Conv Scale	comprehens	apply	2	0	2	0	2	0	0	0	0	
c	Conv Scale	comprehens	apply	2	0	2	0	2	0	0	0	0	
16 a	Conv Scale	comprehens	apply	2	0	2	2	2	2	0	2	0	
17 a	Conv Scale	Conv Scale	apply	2	0	2	2	2	2	0	2	2	
b	Conv Scale	Conv Scale	apply	2	0	2	0	2	0	0	0	0	
c	Conv Scale	Conv Scale	apply	2	0	2	0	2	0	0	0	0	
d	Conv Scale	Conv Scale	apply	2	0	2	2	2	2	0	0	2	
e	Conv Scale	Conv Scale	apply	2	0	2	0	2	0	0	2	0	
18 a	Conv Unit	Conv Unit	apply	4	2	4	4	4	4	0	4	4	
b	Conv Unit	Conv Unit	apply	4	2	4	4	4	4	0	4	4	
c	Conv Unit	Conv Unit	apply	4	0	4	4	4	4	2	4	4	
19 a	Conv Unit	Conv Unit	apply	4	4	4	4	4	4	0	4	4	
b	Conv Unit	Conv Unit	apply	4	4	4	4	4	4	0	4	4	
c	Conv Unit	Conv Unit	apply	4	4	4	4	4	4	0	4	4	
19 a	Conv Unit	Conv Unit	apply	4	2	0	2	2	2	0	0	2	
b	Conv Unit	Conv Unit	apply	4	0	0	0	2	2	0	0	2	
c	Conv Unit	Conv Unit	apply	4	0	0	0	2	2	0	0	2	
20 a	Conv Unit	Conv Unit	apply	4	2	4	2	4	4	0	2	4	
b	Conv Unit	Conv Unit	apply	4	4	4	0	4	2	0	0	4	
21 a	Whole C.	comprehens	analyse	10	0	10	10	10	10	0	10	0	
22 a	Whole C.	comprehens	analyse	10	0	10	0	10	10	0	10	0	
b	Whole C.	comprehens	analyse	10	0	10	0	10	10	0	0	0	
23 a	Applied C	similare trig	apply	6	6	0	0	0	0	0	6	6	
24 a	Applied C	comprehens	analyse	10	0	0	0	10	10	10	10	10	
		<b>Mark</b>		<b>197</b>	<b>79</b>	<b>161</b>	<b>93</b>	<b>185</b>	<b>161</b>	<b>59</b>	<b>145</b>	<b>123</b>	
		<b>Percent</b>		<b>100%</b>	<b>40%</b>	<b>82%</b>	<b>47%</b>	<b>94%</b>	<b>82%</b>	<b>30%</b>	<b>74%</b>	<b>62%</b>	