AN INVESTIGATION INTO THE ROLE OF ATTITUDES TOWARDS MATHEMATICS AS A MOTIVATION FOR CHOOSING VOCATIONAL-TECHNICAL SECONDARY EDUCATION.

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CONTENTS

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INTRODUCTION.

As headmaster of a technical high school it is my responsibility to admit standard six pupils to this school. Often the refrain from parents is heard : "My son is weak in mathematics but good with his hands." These parents desperately seek a secondary education for their non-academic children. To what extent has the vicious circle of low achievement - negative attitude - lower achievement - despair already been established in these pupils as far as mathematics is concerned? How does this low self-concept in mathematics ability serve as a factor in deciding upon which career to follow, which type of high school to attend?

Parents and the public at large seem to be ill-informed about the subjects offered at technical high schools. The mathematical character of these schools is especially undervalued. People often seem to think that the mathematics at a technical high school is easier than at other high schools. Furthermore, people do not realize that mathematics forms the cornerstone of any technical field of study. Failure in mathematics will inevitably lead to low marks or failure in technical subjects. It seems that many pupils who have already developed a defeatist attitude towards mathematics, seek entry into this type of high school. If so, then why?

This study aims to elucidate the mathematical cognitive demands made by mathematically related subjects in a technical high school. At the same time possible relationships will be investigated between choice of type of high school (technical vs non-technical)
and:
- i) attitudes to mathematics
- ii) achievement in mathematics
- iii) general academic achievement
- iv) attitude to school

Pupils at standard five level have already established their attitudes towards subjects. For this study standard five boys from East London English and Afrikaans-speaking primary schools were involved. The reason why girls were not considered was to eliminate the variables of sex-related behaviours. Also, girls do not report in any large numbers for technical education as yet.

The results of this study should be of use to those advising standard five pupils on their choice of type of high school. If satisfactory relationships are found between affective-cognitive variables and choice of high school, future researchers may use this towards the construction of a required profile for prospective pupils of technical high schools.

There are of course, many other factors in the issue. Variables like social status, parents' own experiences, vested interests of academic high schools and many more are not considered in this study.
It is conceded that any in-depth study into attitudes towards mathematics or into choice of type of high school is a many-faceted problem, the scope of which lies beyond this thesis. Suffice to admit that attitudes are complex dispositions resulting from the interactions between a number of affective, cognitive and psychomotor variables.

CHAPTER ONE.

1.0 INTRODUCTION TO OVERVIEW OF RELEVANT RESEARCH LITERATURE.

In studying the relevant research literature, one is struck by the concern educators have about pupils who fail to achieve in mathematics as they are expected to do. Attitudes towards mathematics seem to have become more important in a search for such reasons. No wonder therefore the many studies aimed at relating attitude with achievement.

Freudenthal(1983) said: " .... all major problems of mathematics education are problems of education as such." The complexity of the issue should therefore not be undervalued. The best a study of this nature with its limited scope can thus hope to achieve, is to identify some of the many variables believed to compose the concept attitude and then to relate these to other factors like choice of high school, attitude score etc.

As this study concerns only the attitudes of boys, sex-related behaviours will not be studied in any depth. The many boy-girl differences may therefore receive only passing comments.

No research literature could be found which purported to relate attitude to mathematics, or achievement in mathematics, with choice of type of high school. Whilst this does not seem to have been identified as an issue in the past, the present study may produce some interesting results.

A fair amount of research literature was found concerning spatial abilities and mathematics achievement. By simple extrapolation one could bring these studies in relation with technical drawing which is an important subject in a vocational-technical situation.

1.1 THE CONCEPT 'ATTITUDE'

Minato(1983) says that the ".... word 'attitude' has a wide range of meaning, and a different definition or interpretation of a definition, of the word is used in every study involving attitudes." Allport confirms this saying that "…. the concept of attitude is all things to all men"(Light, 1984). In spite of this vagueness some consensus is evident: Most writers attach to attitude a connotation of 'feeling', 'disposition' or 'willingness' to respond. These characteristics of attitude vary in intensity and can be either positive or negative. In this regard Lindquist(1981) refers to attitudes as " …. feelings about mathematics and feelings about oneself as a learner of mathematics." Thurstone(1974) refers to attitudes as "the sum total of a man's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats and convictions about any specified topic." Osgood et al(1957) refer to 'tendencies of approach or avoidance', and 'favourable' or 'unfavourable' as he assigns a bipolar continuum to attitude. Minato(1983) supports this notion and defines attitude as " …. a learned implicit process which is potentially bipolar, varies in its intensity, and is part of the internal mediational activity that operates between a stimulus and the individual's more overt evaluation response pattern."

1.2 COMPONENTS OF ATTITUDE.

Of interest are the notions of a few writers who view attitude as having essentially three components, namely a belief, an emotion and an action-tendency (Light, 1984). Cook and Selltiz(1964) subscribe to this as they refer to " …. statements of belief and feeling about the attitude object and approach-avoidance actions with respect to it." Krathwohl et al (1964) use phrases like 'emotion', 'willingness to respond' and 'conceptualization of a value' in dealing with attitudes.

1.2.1 The belief component.

Light(1984) says that the belief component of attitudes "…. may consist of sound factual arguments, generalizations, stereotypes, rationalizations of the person's previous actions, totally unfounded notions that were suggested by someone else, or even assumptions of which the person is unaware." Of interest then is to know from where these beliefs have originated. What will make a person 'believe' in a value system? To explain this, Light(1984) quotes Bem(Krech et al, 1974) who suggested vertical and horizontal structures to describe belief structures.

Vertical structure.

If a belief is supported by a rational premise it has a vertical structure. For example: For strong teeth and bones a person needs 0,8 grams of calcium per day. Milk is rich in calcium. A glass of milk contains about 0,6 grams of calcium. Therefore one should drink at least one glass of milk per day(Light, 1984).

Beliefs with no vertical structures are called primitive beliefs. Such beliefs are held by virtue of the authority of someone else. Light(1984) argues that because many of the beliefs of young children are primitive, rational attempts to dissuade them from their beliefs cannot be effective, ".... the arguments and reasoning are simply not relevant to the child's beliefs"(Light, 1984). Whilst this may be the case for very 'young' children, one could, however, expect that 13-year olds are more capable of logical reasoning.

Horizontal structure.

If a belief is supported by independent and parallel premises it is said to have a horizontal structure. The same belief may also have several sets of independent vertical supporting arguments, each one adding to a belief's horizontal structure.

1.2.2 The emotional component.

This component involves our feelings and notions. Attitudes can be pleasant or unpleasant. In mathematics, fear, anxiety and prejudice are some of the negative components of emotion. These emotional components can be acquired through first- or second-hand experiences with subject matter. Light(1984) says: "The emotional component can sometimes be the major determinant of the attitude, overriding all else."

1.2.3 The action-tendency component.

"It is generally true that a change in beliefs and feelings about someone is usually accompanied by a change in behaviour towards that person"(Light, 1984). A person's attitude could even be compounded by a number of incompatible and indefensible feelings about something. The actual concrete behaviour will depend on the situation which exists at the moment and this may be at variance with what the person had said or felt previously.

1.3 ATTITUDE AS PREDICTOR OF ACHIEVEMENT IN MATHEMATICS.

Why all the fuss about attitudes towards mathematics? Apparently educators have a deeprooted intuition that positive attitudes towards mathematics must result in better achievements in the subject. An overview of the relevant research literature produced an abundance of studies which aimed at producing such correlations:

Aiken(1976) quotes a study by Behr(1973) who found that the correlation between attitude and achievement varies with grade level and with sex. For girls the correlation is somewhat higher. Thus girls' marks are more related to their attitudes than are boys' marks.

Neale(1976) in Aiken(1976) found that attitudes is the second most important predictor of achievement, ability being the most important. Concerning attitude as predictor of achievement and grade levels, Aiken(1976) quotes numerous studies showing low but sinificant correlations at elementary (Evans, 1972; Moore, 1972), secondary(Burbank, 1970; Callahan, 1971), college undergraduate (Edwards, 1972; Fennema, 1974) and postgraduate (Webb, 1972) levels.

Cattell and Butcher(1968) in Neale(1969) found that each group of factors accounted for approximately one-fourth of the variation in achievement. For example 25% from ability, 25% from personality, 25% from attitude etc.

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Antonnen(1967), Ryan(1968) and Husén(1967) in Neale(1969) found that self-reported attitude towards mathematics and mathematics achievement were positively correlated in the range 0,2 to 0,4.

1.4 ATTITUDE TOWARDS LEARNING MATHEMATICS AND ACHIEVEMENT.

Neale(1969) quotes the International Study of Achievement in Mathematics (Husén, 1967) which names three desirable objectives of mathematics instruction:

i Mathematics as process

fixed, formal system ; mastery of rigid, unchanging rules	vs.	changing, allows different views; requires understanding.

ii Difficulty of learning

only for elite	vs.	can be learned by anyone

iii Place in society

luxury only	vs.	essential to nation

Negative correlations were found between 'achievement' and attitude towards process and 'difficulty' in the means of pupils from various countries. From this, Neale(1969) infers that ".... groups of students can be produced who achieve well, but who may have undesirable attitudes towards mathematics."

In longitudinal studies, Antonnen(1967) and Ryan(1968) found a decline in attitude towards mathematics as pupils progress through school. One can only speculate at what stage of 'decline' the attitude of standard five boys are.

In what seems a rather pessimistic view, Neale(1969) concludes that: "What makes Sammy learn is not so much that he enjoys discovering the orderliness of mathematical relationships, but that he wants to be an obedient person and do his work." Neale(1969) also refers to the 'hidden curriculum' which requires children to cultivate basic virtues

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like patience, compliance and obedience. He feels that if rather the intrinsic interest in mathematics can be improved, the situation can be changed. This will however, call for more flexible teaching methods and new curricula.

CHAPTER TWO.

2.0 SELECTED SUBCATEGORIES OF ATTITUDE.

In the sections which follow some of the factors which compose of attitude will be discussed.

2.1 MATHEMATICAL SELF-CONCEPT.

2.1.1 Definitions.

Bloom(1976) says that " .... self-concept is an index of the student's perception of himself in relation to the achievement of the other learners in his class"(Mellet, 1983).

Lindquist(1981) says: "Confidence in mathematics has to do with how sure a person is of being able to learn new mathematics, perform well in mathematics class, or perform on mathematics tests."

According to Bloom(1976) and Vrey(1979), a pupil's academic self-concept is established at the end of his primary school years(Mellet, 1983).

2.1.2 Self-concept and mathematics achievement.

As " ....confidence (is) one of the most important attitudes towards mathematics ...." (Lindquist, 1981),it is not surprizing that: "There is evidence that confidence is more strongly related to mathematics achievement than some other affective variables"(Fennema and Sherman, 1977, 1978 in Lindquist, 1981).

Lindquist(1981) quotes numerous researchers who found correlations ranging from significant to moderate in studies relating self-concept with achievement in mathematics(Sherman and Fennema, 1977, 1978; Mellet, 1983). A high academic self-concept seems to favour mathematics achievement. Similar results are reported in studies by Lindquist(1981)

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relating confidence in learning mathematics and mathematics achievement (Sherman and Fennema, 1977; Dowling, 1978).

2.1.3 Self-concept as predictor for taking further courses.

Sherman and Fennema(1977) and Dowling(1978) found that confidence scores were very good predictors of which pupils intend taking more mathematics courses in high school. They also found that boys and girls differed more often about their confidence in doing mathematics than in their actual mathematics achievement.

2.1.4 Formation of a self-concept.

Lorenz(1983) says that ".... the self-concept as a well-defined construct does not exist, but should be split into several parts, each relating to task-specific activities." For example: A pupil could assess his ability in mathematics differently from his English ability, but could also be better in algebra than in geometry.

"Research findings show that mathematics self-concept is built up in an analogous way as concept formation: success and failure lead to tentative hypotheses about one's own ability to cope with difficult tasks, these hypotheses are tested in further activities, and they become stable over time"(Lorenz, 1983).

How does a teacher influence the self-concept of his/her pupils? Light(1984) quotes Lorenz(1982) and Aiken(1970) on this in that teachers' low opinions of their pupils' abilities are likely to result in an unwillingness to interact with or give help to these pupils, which in turn leads to disastrous effects on the pupils' mathematics self-concept. Lindquist(1981) quotes similar studies by Reyes and Fennema (1980) which showed that high confidence pupils interact more often and at higher cognitive levels with teachers than do low confidence pupils. Furthermore, Light(1984) says that pupils readily accept the assigned role as the mathematical underachiever and thereby develop a low mathematical self-concept. He says this usually results from previous poor performances in the subject and ends in the self-fulfilling prophecy,

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known as the Pygmalion-effect(Brophy and Good, 1972, 1974; Lorenz, 1982).

It is to be noted that a positive self-concept can hardly be formed by primitive beliefs. A pupil needs to be convinced that he/she has mastered lower mathematical concepts before feeling confident about taking on more complicated mathematical content. This implies that a pupil's vertical belief structure about his/her mathematical ability, and self-confidence, is very important. Horizontal beliefs may, however, also facilitate the formation of positive self-concepts.

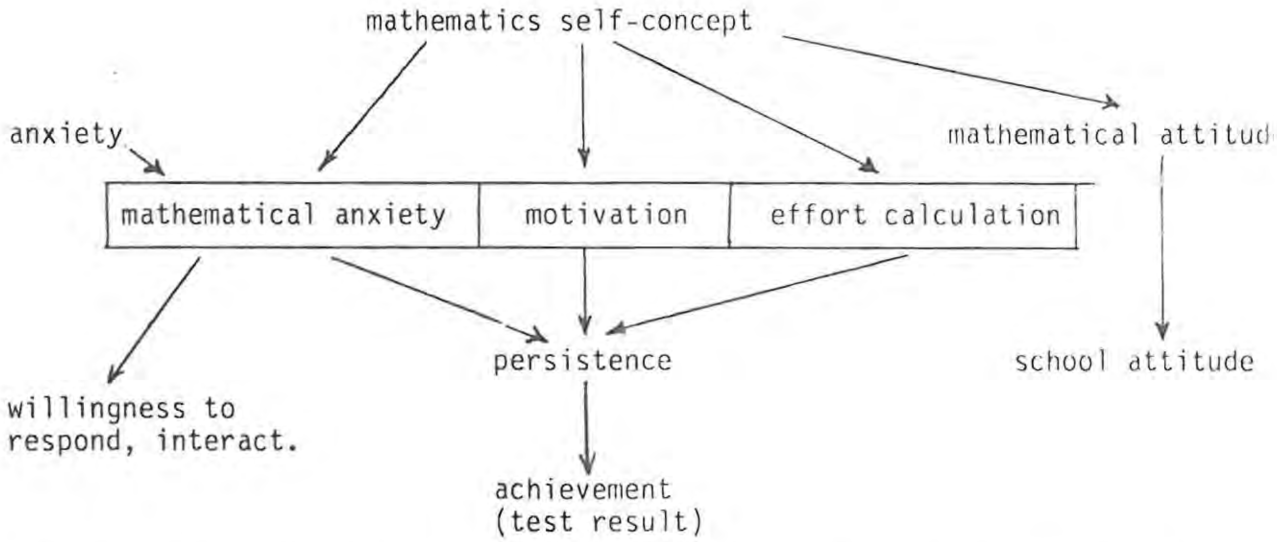
2.1.5 Self-concept and other attitudinal variables.

How does self-concept relate to other attitudinal variables like anxiety, motivation and persistence?

Light(1984) quotes Bloom(1971) who argues that self-concept plays a central role in explaining differences in performance and in task-relevant characteristics such as nervousness, motivation and clasroom participation. Mellet(1983) found a negative correlation ($r = -0,376$) between mathematical anxiety and self-concept. Fennema and Sherman (1976) found similar negative correlations. Lindquist(1981) further argues that since ".... the two attitudes are closely linked, it makes sense to think of them as one attitude with confidence as its positive manifestation and anxiety its negative one."

Lorenz(1983) says: "Data from studies in general psychology confirm the close relationship between self-concept and persistence at difficult tasks." Pupils with high self-confidence invest more effort when failing at a mathematics problem because this seems promising to cope with the task. "The construct that links self-concept and persistence is effort calculation "(Lorenz, 1983). Anxiety as ".... fear of failing at a task ...." and motivation as " .... hope for success ...." both ".... influence students' willingness to persist at difficult tasks"(Lorenz, 1983).

PROCESS MODEL OF AFFECTIVE STUDENT VARIABLES (Lorenz, 1983)



In an overview of her findings Hoyles(1982) reports as follows on pupils and their feelings about their own mathematical self-concept:

".... pupils were much more concerned with their own role in relation to learning mathematics than learning other subjects. Pupils had strong ideas about what they were capable of doing and what they were capable of understanding in mathematics and their mathematical experiences were dominated by this focus on self and feelings about oneself"(p367), ".... it was when a pupil failed to reach his or her particular goal, whatever it happened to be, that he or she began to doubt his or her ability"(p360). ".... anxiety, feelings of inadequacy and feelings of shame were quite common features of bad experiences in learning mathematics"(p368).

Hoyles(1982) says pupils want plenty of patience, encouragement and structure from their teachers in order to boost their self-confidence. They want to finish their mathematics quickly so that they may know whether they have it correct. (probably to shorten the period of anxiety) This, however, leads to absence in involvement in the subject(Lefcourt, 1976) and also explains why anxiety in mathematics tends to be debilitating

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rather than facilitating(Hoyles, 1982).

A teacher should be aware of the mathematical self-confidence of his/her pupils and realize the effect this can have on their performance. In order to boost confidence, teachers should adapt their teaching styles to allow for individual differences(Hoyles, 1982).

2.2 ANXIETY.

2.2.1 Concept anxiety.

Mellet(1983) quotes the following definition of anxiety by Sartre: Anxiety is ".... a fear of failure to measure up to internal perceived external standards, and a fear that one's own standards are not appropriate or good enough." Further to this, Ausubel(1968) refers to the tendency to behave in an anxious way in situations which may threaten the positive self-concept. From these definitions, Mellet(1983) concludes that a feeling of helplessness lies to the root of anxiety.

2.2.2 Anxiety and fear.

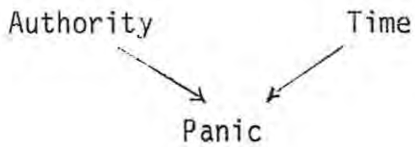
Fear results from situations which do exist for the pupil, that is, situations which are objective dangers for the pupil(eg. a fear for punishment). On the other hand, anxiety results from a subjective internal problem which the pupil cannot solve. Example: A lack of self-confidence that a person will not be capable to meet expectations in a particular situation(Mellet, 1983).

2.2.3 Trait-anxiety and state-anxiety.

Trait-anxiety refers to general anxiety. Some people have as part of their personality, general anxious feelings. Lorenz(1983) says that ".... research on the differential effects of these anxieties showed that trait-anxiety only indirectly influences mathematics achievement via state-anxiety, the latter having direct impact on the learning and problem solving process." State-anxiety here is thus mathematics anxiety and Lindquist(1981) says that it "....interfere(s) with the manipulation of numbers and the solving of mathematical problems." Lorenz(1983) confirms this saying that: "State-anxiety exceeding a critical value prevents hypothesis generation in problem-solving tasks."

2.2.4 <u>Anxiety and panic.</u>

Buxton(1983) provides an interesting way how panic in mathematics forms. He says that the feedback of success leads to emotional responses on the "pleasure -unpleasure spectrum." He proposes that panic results from a variety of elements which could be grouped under two main headings of 'authority' and 'time':



If the pupil cannot provide "a plan" quickly enough to solve a problem, a "state of immobility" is formed and panic sets in. Panic can thus be regarded as the culmination of intense anxiety.

2.2.5 <u>Anxiety: only debilitating?</u>

Mellet(1983) quotes studies by Blumberg(1969) which showed that pupils with moderate feelings of anxiety achieve significantly better than others with either very low or very high feelings of anxiety. Lorenz(1983) confirms this saying that correlational studies on anxiety and mathematics achievement "....(are) not linear but rather of an inverted U-shape." The implication is clear: Provided the situation does not cause too much anxiety, it is helpful. This may, however, depend on how complex the task looks to the pupil. In this regard Lindquist(1981) says that anxiety ".... may, however, be helpful or

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facilitative in learning and performing simple tasks. In contrast, anxiety is often detrimental and debilitating to performance on complex tasks." Nijhawan(1972) confirms this as he says: "mild anxiety is not inhibitary; actually it spurs the person on to new achievements" (Mellet, 1983).

These findings seem to support a general intuitive feeling amongst teachers that pupils need that little bit of motivation, even threatening to a small degree, to produce better results.

2.2.6 Anxiety and other attitudinal variables.

Lindquist(1981) argues that anxiety focusses attention away from the task and into internal negative self-talk, "....such as 'I am stupid' or 'I know I can't learn mathematics'." Vrey(1979) confirms this notion as he argues that self-concept and anxiety are inversely proportional to each other (Mellet, 1983).

Lorenz(1983) states that motivation and state-anxiety are also inversely proportional to each other, "....with high state-anxiety reducing the motivation to undergo mathematical tasks."

2.2.7 The adolescent and general anxiety.

Mellet(1983) says that between the ages twelve and twenty years the pupil undergoes physical and emotional changes. During this period the adolescent experiences pressures on him/her to compete with others in a variety of ways. This causes anxiety. Other factors arousing anxiety are the battle to establish an own identity and the social pressures to suppress spontaneous expressions of emotions. This general anxiety can then add to the state-anxiety, arising from a particular situation, in order to produce a level of overall anxiety which is debilitating.

2.2.8 Anxiety and mathematics achievement.

Light(1984) quotes numerous investigators (Aiken, 1970;

McGowan, 1960; Reese, 1961), who reported small positive correlations between anxiety and mathematics achievement. Females were found to be more prone to anxiety, as an inhibiting factor, than were males (Aiken and Dreyer, 1961; Rees, 1961) in Light (1984).

Does anxiety play a role at all levels? Lindquist(1981) reports that consistent negative relationships were found between anxiety and mathematics achievements for students from grade school through to college(Aiken, 1970a, 1970b, 1976; Betz, 1978; Callahan and Glennan, 1975; Crosswhite, 1972; Sarason et al, 1960; Szetela, 1973). Lindquist(1981), however, warns that none of these studies has demonstrated a clear cause-effect relationship. We still do not know whether low achievement in mathematics produce high levels of anxiety or vice versa.

What is the relative contribution of general anxiety and mathematics anxiety towards mathematics achievement? Mellet(1983) quotes a study by Sepie and Keeling(1978) who found the latter to have the greatest negative influence on anchievement.

2.2.9 Programmes to reduce anxiety.

If too much anxiety reduces competence in mathematics, then programmes aimed at reducing it should improve competency. Lindquist (1981), however, reports that very few of such programmes succeeded in achieving this. The complexity of the task seem to be the vital factor, as was shown in a study by Crumpton (1977) where college students were given extra instruction in high anxiety low competency content areas, causing improved competence in mathematics and a lowering of anxiety about mathematics.

In the classroom the experienced mathematics teacher should know beforehand which mathematics content will arouse too much anxiety or too little anxiety. He/she will then adapt the teaching style to keep levels of anxiety at an optimum value for the class. At the same time allowances should be made for individual differences.

2.3 ATTRIBUTION.

2.3.1 Concept 'attribution'.

Lindquist(1981) says attribution "....deals with an individual's beliefs about the causes of behaviour, in particular the reasons that one succeeds or fails in a variety of experiences." For example: One person may believe his/her success is due to hard work while another may put it down to mere luck.

2.3.2 Categories of attribution.

Weiner(1972) arranged these beliefs into four categories along two axes, locus of 'causality' and 'stability':

Perceived causes of success/failure

Stability	Locus of Causality	
	Internal	External
Stable	ability	task difficulty
Unstable	effort	luck

Internal causes are within that person and can be controlled by himself (eg. intelligence, effort, paying attention in class etc.)

External causes are outside the control of that person (eg. quality of explanations, difficulty of test items etc.)

The stable/unstable dimension refers to whether the factor varies from time to time. (eg. luck will vary but ability will remain the same)

2.3.3 Attribution and self-concept.

Ickes and Layden(1978) found that "....people with low self-concepts more often ascribe positive outcomes to external causes, while tending to attribute negative outcomes internally"(Lindquist,1981).

Males and females seem to differ in their patterns of attribution: Deaux(1976) found that females "....hold lower expectations of their own performance than males do of theirs." When females are successful they put it down to unstable external causes (eg. luck) and when they fail they believe it to be because of stable internal causes (eg. lack of ability). Males attributes success to ability and "....to search for unstable external causes to explain failure"(Lindquist, 1981).

2.3.4 Attribution and expectancies.

As can be expected, attribution and expectancies are closely related. Deaux(1976) found that those who started off with a high degree of self-confidence (i.e those with high expectancies) attribute failure externally and success internally, while just the reverse holds for those initially low in confidence.

2.3.5 Attribution in the self-perpetuating cycle.

Lindquist(1981) hypothezises a self-perpetuating cycle for subjects low in confidence: "Low confidence, internal attribution of failure, and external attribution of success may exist, which in turn can affect achievement or decisions to take more mathematics."

2.3.6 Attribution and persistance.

Do subjects still persist, even if they believe that their failures are due to stable causes? (eg. ability or difficulty of examinations). Weiner et al (1972) found that such subjects tend to persist less. On the other hand it was found that if the cause of failure is believed to be unstable, (eg. bad luck or lack of effort) the failure tends to be met with greater persistence.

2.3.7 Attribution and motivation.

How do people attribute their successes/failures if they are in great need to achieve? (achievement motivation) Lindquist(1981) quotes Bar-Tal(1978) who found that those high in need to achieve tend to attribute success to internal causes, (eg. ability or effort) whilst those low in need to achieve, attribute their success to external causes (eg. luck or easy papers).

2.3.8 Classroom implications of attribution.

Lindquist(1981) believes that "....teachers should be aware of students' attributions of success and failure," but that teachers should also monitor their own attributions why their pupils failed or succeeded. Are these perspectives of the pupils and their teachers the same or do they have differing reasons for failure/success? Lindquist(1981) concludes: "It certainly seems logical that people should feel they have some control over their lives and their learning of mathematics. If students believe that effort is a cause of success and failure, perhaps they will also see that they can have some control over the mathematics they learn by controlling the amount of effort they exert."

2.4 PERCEIVED USEFULNESS OF MATHEMATICS AS AN ATTITUDE.

To what extent has perceived usefulness of mathematics an influence on pupils' attitudes? Does this affect their achievement in the subject at all and do girls and boys differ in this respect?

2.4.1 Usefulness and mathematics achievement.

Perl(1979) and Fennema and Sherman(1977, 1978), found that among middle and high school pupils, the high scorers see mathematics as more useful than the lower achievers do. Mellet(1983) found a positive correlation between achievement and interest in mathematics. An 'interest in' mathematics may be viewed here as also 'noting its value, either as tool or art.'

2.4.2 Usefulness and further course participation.

Light(1984) quotes the Encyclopedia of Educational Research, (1982) which claims that "Positive attitudes towards mathematics and the perceived usefulness of mathematics are highly correlated with mathematics course participation." Perl(1979) confirms this as she found that "....views on the usefulness of mathematics discriminated between students who elect and students who do not elect to take more mathematics courses."

Hoyles(1982) refers to pupils who failed to reach their goals in mathematics and quoting them as reporting:
"Pupils did not talk about what their mathematics was about, or how it may be used. They did not appear to see that the subject should be of any interest in itself but only as something to be done, something to be mastered, something with an existence of its own."

2.4.3 Usefulness and boy/girl attitude.

Perl(1979) "...identified perceived usefulness of mathematics as the most important attitudinal factor in explaining the differences in mathematics course election between boys and girls." A few other researchers reached similar conclusions(Haven, 1971; Hilton and Berglund, 1974).

2.4.4 Perceived usefulness as easy attitude to change.

Lindquist(1981) argues that of the four attitudes discussed thus far, "....usefulness may be the easiest attitude to ahange, and teachers are in the best position to bring about change ...."

Light(1984) says that teachers should point out the value of mathematics to their pupils from a very early age and this process should be continued throughout a pupil's school life.

Strasser(1983) reports on the situation in Germany and puts some blame on teachers as he argues: "Apprentices often fail because they cannot correctly relate mathematics and the vocational situation; they have not learned to apply mathematics."

Lindsay(1983) probably sums up the situation well as he refers to the apparent bivalent attitude pupils have towards mathematics: "At school I liked arithmetic, and I like it now, and I find it useful, but the rest of maths is rubbish." He continues and asks: "The problem for the teacher is how to maintain balance between the cultural aspects of mathematics and its utilitarian content - i.e., between mathematics as queen or servant."

As will be pointed out in the chapter "meaningful learning," parts of the mathematical syllabus find immediate practical use in a vocational-technical situation. This, pupils readily accept, but how do they feel about the rest of the syllabus?

2.5 MOTIVATION.

Lorenz(1983) refers to motivation as "....hope for success ..." and says that both anxiety and motivation influence a student's willingness to persist at difficult tasks. Also every other subcategory of attitude affects motivation in one way or another.

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Motivation forms an integral part in Lorenz's(1983) model of affective student variables towards mathematics achievement. (quoted earlier in section 2.1.5) In this regard Light(1984) quotes a study by Wade(1981) who found a positive relationship between motivation and achievement in mathematics.

Motivation can be intrinsic or extrinsic:

2.5.1 Intrinsic motivation.

Intrinsic motivation deals with drives from within a person and which may culminate in spontaneous activity. Examples of such motivations are: Feeling confident about one's mathematics ability; appreciating the aesthetic or technological value of mathematic; having a home background which supports virtues like perseverance and diligence; having an inherent drive to achieve and compete with others.

Intrinsic motivation is the ideal of every teacher for his/her pupils. Neale(1969) refers to his "romantic view" where the school should be a place "....where necessary tasks are made attractive and rewarding, where every motivation children have is used to encourage learning."

2.5.2 Extrinsic motivation.

Extrinsic motivation deals with drives external to a person and which may culminate in activity. This activity is, however, not spontaneous like in intrinsic motivation. Extrinsic motivation is more like a stimulus-response situation where factors like parental expectations or peer influences serve as stimuli.

2.5.2.1 Peer pressure and influences from home.

Thirteen year-olds experience marked changes as they develop physically and socially. Self-awareness grow and they have a dire need to be accepted by their peers.

Callahan(1971) and Taylor(1970) note that the late elementary and junior high school grades are particularly important years in the development of attitudes towards mathematics.

Johnson(1972) found that college students are attracted to peers who have similar attitudes towards mathematics and dislike others with opposite attitudes.

Light(1984) quotes Shapiro(1962) who found that the influence of peers on attitudes towards mathematics is of particular importance in the case of girls.

To what extent can parent's motivation affect their childrens' attitudes?

Light(1984) argues that too high or too low parental expectations may both have adverse effects on the attitudes of their children towards mathematics. He says further that encouragement (i.e. motivation) by parents will act positively on childrens' attitudes, and that the example set by the attitudes parents <u>themselves</u> have towards mathematics, are very influential.

As pupils progress through school their parents find it increasingly difficult to assist them with mathematics. Light(1984) quotes Aiken (1970) and Karos(1964) who found that the home invironment has a greater influence on the more verbal subjects, rather than on mathematics.

2.5.2.2 <u>Classroom and school</u>.

How does attitude towards the school in general influence motivation and achievement?

Mellet(1983) found that pupils with strong positive attitudes towards the school achieve significantly better in mathematics than pupils having only a moderately positive attitude towards school.

Aiken(1961) found that "....mathematics attitudes are thus apparently related to remembered impressions of teachers, the females more clearly so than the male attitudes."

Teachers and teaching practices have a marked influence upon pupils' attitudes towards mathematics and their achievements in the subject (Aiken, 1970 and Banks 1964 in Light, 1984). These findings are supported by Lyda and Morse (1963) who found that pupils were more positively predisposed towards mathematics when teachers used meaningful methods of teaching rather than rote learning.

Many other classroom and school influences can also serve to motivate pupils towards participation, meaningful learning and the cultivation of positive attitudes towards mathematics. For the purpose of this study it is, however, not considered applicable to explore these any further.

CHAPTER THREE.

This and the next two chapters will deal with the domains into which mathematics is usually categorized, viz the cognitive-, affective- and psychomotor domains.

Of particular importance to this study will be the interaction between the domains. It is believed that the entire concept of such interaction, and hence meaningful learning, hinges on favourable attitudes towards mathematics.

Education and specifically mathematics education is too an important activity to be tackled in any haphazard way. For this purpose, educational psychologists have developed taxonomies of objectives of mathematics instruction. These taxonomies are hierarchical classification systems which specify the behavioral outcome of educational systems. Firstly then the cognitive domain and Bloom's taxonomy.

3.0 COGNITIVE DOMAIN.

Bloom(1956) defines the cognitive domain as "....those objectives which deal with the recall or recognition of knowledge and the development of intellectual abilities and skills ...."

As mathematics and related subjects involve a great deal of intellectual activity, it deserves to be studied more closely. For this Bloom's Taxonomy of Educational Objectives will now be examined.

3.1 BLOOM'S TAXONOMY

Bloom(1956) identified and arranged into a hierarchical order six cognitive classes. From the simplest to the most complex they are:

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1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation

Each of these classes will now be studied with special reference to the implication each has on Mathematics, Physical Science, Technical Drawing and other Technical Subjects(eg. Television and Radiotrician-work, Electricians-work, Motor Mechanics, Woodworking and Fitting and Turning).

3.1.1 Knowledge

Knowledge involves the remembering and recalling of information in the same form pupils received it. Understanding is not necessarily necessary at this level. Pupils merely have to reproduce proofs, know procedures or terminology, and have mastered skills.

Examples of Test Items

Mathematics: State the conditions for two triangles to be congruent (std. seven)

Physical Science: State the properties of a Vector(std. nine)

Woodworking: Use the radial method of proportional enlarging to draw a mould enlarged double size(std. ten) -annexure

Technical Drawing: Construct two triangles from given data and then construct two inscribed and escribed circles for these(std. six) - annexure 1

3.1.2 Comprehension

Comprehension involves the lowest level of understanding ideas and manifests itself if a pupil can make some use of it, ".... without necessarily relating it to other ideas or understanding all of its implications"(Bell, 1978). Comprehension can be further subdivided into:

i Translating - translating verbal statements into mathematical symbols

ii Interpretation - ability to formulate new viewpoints of material

iii Extrapolation - extending trends beyond given data

Examples of Test Items (only extrapolation)

Mathematics	:	State the domain of the function xy = 1 (std. ten)
Physical Science	:	Use the graph of pressure vs temperature to deduce the absolute zero (std. ten)
TV and Radio	:	A circuit has a resonance frequency of 1 MHz. Deduce what the capacitance and inductance should be for its optimum use.(std. ten)...annexure 2
Technical Drawing	:	Given the front and top views of two lines which are both inclined to the horizontal and vertical planes. Determine the true lengths of these lines and the shortest distance between them.(std. ten) ... annexure 2

3.1.3 Application

In application a pupil must not only be able to use a mathematical concept correctly, but also to select the correct one and apply it in a problem which is novel to the student. This means that any routine tasks which involve only knowledge and understanding, will not be classified as application. Sometimes "....novelty is mistakenly equated with the notion of complexity. The ability to use 15 rules in a long calculus problem is still level II behaviour if the problem is a typical one, whereas the ability to select the correct rule, however simple, in a situation new to the student is level III behaviour"(Farrel and Farmer, 1980).
(See annexure 3 for examples of test items)

A pupil who has learned his basics, understands it but lacks experience in applying it may face many 'novel' problems in an examination. Afterwards this pupil would describe the paper as 'difficult'. The less intelligent but hard worker would find the same paper easy, simply because of the more time the latter used working out extra problems from the textbook. These extra problems become 'routine' tasks for the industrious student, but application to the others.

Needless to say, schools are crammed with pupils who fall into this last category. That is pupils who are of average or above intelligence, understand the work in class, but who have developed lazy study habits over many years. They have never learned 'how to learn'. At the senior secondary level, teachers of mathematics and mathematically related subjects are almost fully occupied trying to teach these youngsters to 'think for themselves' and to develop sound study habits. No wonder thus that almost all high school mathematics ends at this level. It has become the supreme objective of teachers to get their pupils to master this level of intellectual activity, let alone developing further cognitive levels or even the cultivation of any liking for mathematics. On the contrary, many pupils dislike mathematics and the mathematical parts of technical subjects.

3.1.4 Analysis and Synthesis

Analysis involves the breaking down ".... of a mathematical structure into its components so that the relative hierarchy and relationship of ideas becomes apparent"(Bell, 1978).

Analysis is usually accompanied by synthesis (putting parts together) and these are activities every mathematics teacher undertakes when new work is introduced to pupils. A complex structure is usually broken down into a set of simpler steps. This is then followed by a given novel problem where the parts are put together in order to solve it.

Examples of Test Items (Analysis - see annexure 4

Examples of Test Items (Synthesis) - see annexure 4

Abilities in analysis and synthesis only follow after thorough mastery of comprehension and application. Few high school pupils progress to this cognitive level, often because of poor teaching styles, pressures of examinations which mostly test only up to application, and adverse affective variables. Analysis and synthesis are often used in problems requiring long complex answers composed of a series of intricate steps. These types of problems demand a relatively high degree of concentration and devotion from pupils; qualities which in turn reflect a high level of affective development and positive attitudes. Lastly, to teach pupils to analyse and synthesize is not easy. How must a pupil be taught to prove novel geometry riders, for example? Intuition, imagination and creative abilities are intellectual activities which are necessary here, but which are not easily taught.

3.1.5 Evaluation

Evaluation involves the judging of material or processes. This is the highest cognitive level and may require the use of all the other levels.

Evaluation can be applicable to students of all standards in secondary school. It is, however, seldom emphasized in most mathematics classes (Bell, 1978). The reason for this is apparent from the discussion on analysis and synthesis.

Teachers, however, often use evaluation in order to justify the introduction of a new process or new theory.

Examples of Test Items - see annexure 5

3.1.6 SUMMARY

Bell(1978) summarizes the cognitive levels and Bloom's taxonomy well as he warns:

"The lower level objectives of knowledge, comprehension and application, and the higher level objectives of analysis, synthesis, and evaluation, are equally important in secondary school mathematics... ...The initial goal of mathematics education should be to teach basic skills which can be used to learn more complex mathematical concepts and principles, and which will support important, practical applications of mathematics."

In a vocational-technical situation this approach is very important. After all, mathematics serve as an invaluable tool to solve the problems in the other mathematical-technical subjects. Cognitive failure in mathematics will inevitably lead to failure in these subjects, general frustration and despair. Furthermore, technical drawing and each technical subject produces its own share of higher cognitive abilities and should therefore not be undervalued as being easy options in the school curriculum. In fact, this is one of the misconceptions about vocational-technical education that these subjects involve, 'working with your hands', and require little cognitive abilities. It may therefore be useful to investigate some of the mathematical-cognitive aspects of these subjects.

3.2 MATHEMATICAL-COGNITIVE DEMANDS OF TECHNICAL DRAWING.

At the very important interface between technology and mathematics lies technical drawing, with 'spatial ability' as the common denominator. No engineering activity can escape the planning stages at the drawing-board. A good sense of spatial ability and imagery are necessary to interpret and visualize the information a technical drawing portrays.

The teaching of technical drawing at school level is in the first instance an educational aspect which aims towards the maturation of a pupil within the society. To this end the propadeutic value of the subject in preparing pupils for further studies in technology and developing spatial abilities can hardly be overestimated. Simultaneous to this one would expect, as a spin-off, greater mathematical proficiency as abilities like visual imagery and spatial orientations develop. This would seem a fair corollary as a substantial section of the technical drawing syllabus overlaps with that of mathematics, especially as far as geometry, interpretation of figural information and construction techniques are concerned. Technical drawing and mathematics are mutually supporting subjects.

The nature of technical drawing is evident on account of three aspects:

i Graphical design which is to be distinguished from verbal-logical thinking.
ii Graphical communication, as a universal language.
iii Two and three-dimensional visualizations.

Knowledge of the above aspects will enable one to:

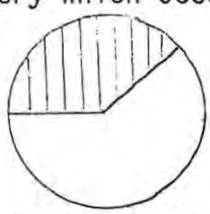
i Interpret('read') a drawing.
ii Obtain certain information from the drawing.
iii Represent ideas graphically.
iv Obtain basic insight necessary for two- and three-dimensional representations.
v Gain basic psychomotor skills required in line work, free-hand sketching and drawing.
vi Gain perspective into isometric and axiometric projections which include mental geometrical rotations.
vii Learn about construction methods.

3.2.1 Spatial ability.

Studies into spatial ability produced its own share of terminology. Researchers(Lean and Clements, 1981) refer to:

i Spatial ability as "....the ability to formulate mental images and to manipulate these images in the mind."
ii Imagery as "....the occurrence of mental activity corresponding to the perception of an object, but when the object is not presented to the sense organ."

iii Visual imagery as "....imagery which occurs as a picture in the 'mind's eye'."

example : one-third as 

Bishop(1983) proposes two kinds of ability in the spatial/mathematical interface:

i The ability for interpreting figural information (I.F.I.) "IFI involves knowledge of the visual conventions and spatial 'vocabulary' used in geometric work, graphs, charts and diagrams of all types. Mathematics abounds with such forms and IFI includes the 'reading' and interpreting of these. It is an ability of content and context, and it concerns the form of the stimulus material presented."

ii The ability for visual processing (VP) "VP, on the other hand, involves the ideas of visualization, the translation of abstract relationships and non-figural data into visual terms, the manipulation and extrapolation of visual imagery, and the transformation of one visual image into another. It is an ability of process."

Bishop(1983) distinguished between low-level and high-level spatial abilities : "In Bloom's(1956) terms IFI is a relatively low-level ability concerned with understanding and interpreting various stimuli." In a further comparison, Guy and McDaniel(1977) also contrast low-level spatial abilities as those "....requiring the visualization of two-dimensional configurations, but no mental transformations of these visual images, with high-level spatial abilities; "....requiring the visualization of three-dimensional configurations and the mental manipulation of these visual images."

From the above, an example of a low-level ability in terms of IFI would be to recognize the symbol ||| as representing similarity and understanding what this means (mathematics) or to recognize the convention 1:100 and understand that it means that every one centimeter on a drawing represents 100 cm in real life (technical drawing). This also refers to two-dimensional configurations which are not manipulated. In brief, low-level spatial ability can be summed up as referring to static situations.

On the other hand, high-level spatial abilities are characterized by movement and rotation, ie. processing of mental images (V.P.) A pupil in mathematics would for example have to visualize a geometric shape superimposed onto another for purposes of comparison(eg. similar triangles). In technical drawing a certain view of a machine part will have to be rotated mentally through a specified angle and a new mental image formed. Shepard and Metzler(1971) say : "Humans can often determine that two-dimensional pictures portray objects of the same three-dimensional shape, even though the objects are depicted in very different orientations." This comparison involves imagining of "....one object as rotated into the same orientation as the other." According to these criteria of high level spatial abilities, technical drawing and technical subjects abound with examples of visual processing and mental rotations of images.

2.3.2 Individual differences

Krutetskii(1979) divides individuals into three categories as far as processing mathematical information is concerned:

- i Analytic type who prefer verbal-logic mode to visual-pictorial modes.
- ii Geometric type who prefer visual-pictorial modes.
- iii Harmonic type who uses both modes freely.

A number of other researchers(Menchinskaya, 1969; Poincaré, 1963; Richardson, 1969, 1977 and Walter, 1963) also content that individuals can be classified into 'verbalizers', 'visualizers' and 'mixers'.

At once many questions spring to mind. Which is the best mode to use? Do people using one or the other mode achieve better in mathematics (and technical drawing)? Not surprizing that Bishop(1980) says that the extent to which individuals use visual ideas in solving mathematics "....is one of the most frequently occurring differences in the mathematics literature." Einstein is reported to have said that he "....always thought about anything in terms of mental pictures and that he used words in a secondary capacity only"(Lean and Clements, 1981). On the other hand Bishop(1980) says that the "....relationships between spatial ability and mathematical ability differ from one student to another." Myers(1958) also says that individuals solve spatial problems idiosyncratically.

To add to the variety of differences, Mitchelmore(1980) reports that boys outperform girls on spatial tasks at each grade level.

Studying undergraduate students, Barratt(1953) found that those students who used visual imagery most, perform better on a battery of tests (Space tests, Flags, Spatial Equations, Cube Surfaces, Raven's Progressive Matrices, Minnesota Paper Form Board) and especially well on those tests with loadings high on spatial manipulation. Some tests had high loadings on reasoning factor and on these the students using imagery were no better than those who made no use of imagery.

Lin(1979) argues that it may even be a disadvantage to someone using visual imagery extensively, to solve mathematical problems. Twyman (1972) also warns that strong visual imagery can interfere with the solving of mathematical problems as a result of the difficulties in decoding imagined images. The image may for example possess details which are irrelevant and lead to the distraction from the original problem. Radatz(1979) also warns that pupils with spatial weeknesses can experience greater difficulties when faced with ikonic mathematical situations because of the greater demands on information processing.

3.2.3 Spatial ability and mathematical ability

In spite of individual differences and in spite of Bishop's (1980) doubt that spatial ability as a key ability to mathematical ability has not been proved, the literature abounds with studies showing relationships between spatial- and mathematical ability.

Amongst many mathematics teachers there is a tenacious, and intuitive belief, that there are strong relationships between spatial and mathematical abilities. No wonder thus that early and recent writers continue to refer to and explore this subject. Hamley(1935) already refers to mathematical ability as "....a compound of general intelligence, visual imagery and ability to perceive number and space configurations and to retain such configurations as mental pictures." But also recent writers; Fennema(1979), Webb(1979), Sherman(1979), Smith(1964), Lean and Clements(1981), Guy and McDaniel(1977) and Moses(1977, 1980) refer to the supporting role spatial abilities have towards mathematical abilities and mathematics achievement.

Although no research literature was found which relates mathematical abilities directly with technical drawing, the findings about visual-spatial demands of mathematics may well hold largely for technical drawing as well.

Webb(1979) studied high school pupils and found that of the thirteen component variables considered, the three which accounted the most for the variance in problem solving were mathematics achievement, pictorial representation and verbal reasoning. Of these, pictorial representation was interpreted to represent a process related to drawings or using pictures, and was a process factor. Mathematics achievement and verbal reasoning were conceptual knowledge. Webb (1979) "....concluded that the fact that the heuristic components, in particular pictorial representation, accounted for a sizable proportion of the variance in scores .... suggests that the use of such processes are important in solving problems."

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Sherman(1979) studied senior high school pupils and found that the spatial ability was one of the most important factors which affected mathematical performances. In dealing with gifted mathematicians, however, Krutetskii(1976) concluded that these students do not always possess above-average spatial abilities and that they often prefer to use solution methods which use little spatial ability.

Smith(1964) in Guay and McDaniel(1977) concluded "....that spatial ability is positively related to high-level mathematical conceptualization, that is, people who can solve high-level mathematical problems generally have greater ability than people who cannot solve these problems." He furthermore concluded from the literature that low-level mathematical conceptualization which stresses simple calculation skills, has little to do with spatial abilities.

In a study by Guay and McDaniel(1977) they found that among elementary school children, low mathematics achievers have less spatial ability than high mathematics achievers. They also concluded that this relationship applies to all elementary grade levels and is independent of sex. Hence they say that low-level mathematical tasks at elementary level are also related to low level spatial abilities, a contradiction of Smith's(1964) contention. Lean and Clements(1981) quote studies by Moses(1977,1980) amongst elementary school children, from which she concluded that spatial ability is a good predictor of mathematics problem-solving performance.

In which parts of mathematics and technical drawing will pupils with poorly developed spatial abilities experience difficulties? Lean and Clements(1981) list the following : Sketch graphs, conic sections, interpreting or drawing two-dimensional representations of three-dimensional situations(engineering drawings) and geometrical transformations(translations, reflections, rotations, dilations, expansions). Mitchelmore(1980) says that: "Spatial ability has been found to be a valid predictor of performance in a wide range of technical-industrial tasks ...."

3.2.4 Improving spatial abilities

Bishop(1980) refers to Thurstone's notions of 'primary abilities' which may combine to produce mathematical abilities. If these do exist, Bishop(1980) contends that mathematical ability can be developed by not just teaching mathematics. He proposes a core school course on 'graphicacy' to improve spatial abilities. Bruner (1973) also refers to the training of 'subtle' spatial imagery and concludes: "I don't think we have begun to scratch the surface of training in visualization"(Bishop, 1980).

Detailed analysis of the sub-skills necessary to complete a spatial task is of course not new to teachers of technical drawing. Unfortunately this approach to spatial training has not been fully recognised by the mathematics education community(Bishop, 1980). However, teaching pupils to imagine and visualize is very much more difficult than teaching ideas about geometric properties, terminology, or even relationships(Bishop, 1983).

Technical drawing as subject can serve as one of these 'subtle spatial imagery' techniques to improve both low-level and high-level spatial abilities. This in turn could promote the ease with which spatial problems in mathematics are taught.

3.2.5 Meaningful learning

Bishop(1983) feels that "....the reason many children turn away from mathematics is their dissatisfaction, and unhappiness with an excel of logico-analytic methods. I think that many of them are predisposed more towards Visual Processing, but teachers and texts are not stimulating or rewarding that ability." Adding to this is Mitchelmore(1980) who noticed that English teachers used diagrams and physical models much more than American teachers. He then found that the English pupils were three years ahead of their American counterparts

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in both spatial and three-dimensional drawing abilities.

Bishop(1973) feels that the mere handling of 3-D shapes in a structured learning situation may promote growth in spatial ability. This is of course exactly what happens in technical drawing and other technical subjects where pupils handle physical models before attempting to draw various views, projections and rotations of these. Would it then not be a fair deduction to contend that these technical subjects play an important role towards meaningful learning?

How does hemispheric specialization affect meaningful learning? Elliot(1980) divides the human brain into two minds, one rational-linear and logical (left brain), and the other metaphoric-intuitive and analogic (right brain). Jerome Bruner(1962) also refers to the rational as opposed to the metaphoric mind.

Elliot(1980) divides the functions of the two hemispheres as follows:

LEFT	RIGHT
Order	Image
Time	Space
Verbal	Visual
Reason	Fantasy
Logic	Analogic

When left to their own, all healty human beings will integrate the use of both hemispheres when tackling a problem. However, an over-emphasis on computational skills (eg. rote learning or drills on algorithmic procedures) will not develop the right brain, and "....the opportunities for meaningful learning are diminished"(Elliot, 1980).

This same notion is echoed by others(Ausubel amd Robinson, 1969, and Grayson and Wheatley et al, 1977). Meaningful learning takes place by an integrated use of both hemispheres of the brain.

The National Council of Supervisors of Mathematics list the following skills pertaining to the hemispheres(Elliot, 1980) :

LEFT BRAIN	RIGHT BRAIN	LEFT AND RIGHT BRAIN
predicting	graphing	applying math. to everyday situations
estimating	geometry	problem solving
computation	measurement	alertness to reasonableness of results
		computer literacy

Where the activities of the left brain are often over-emphasized, it serves well to put special effort into developing the right brain. Unfortunately this is more difficult to do than verbal-logical tasks (left brain activity). Subtle, indirect techniques may therefore be the answer and technical drawing may just be the appropriate school subject to achieve this.

3.3 MATHEMATICAL-COGNITIVE DEMANDS OF TECHNICAL SUBJECTS.

In this paper 'technical subjects' will refer to those subjects offered only at technical high schools. These subjects can be divided into three main categories, namely: Electrical, Mechanical and Civil.

Examples:

ELECTRICAL	MECHANICAL	CIVIL
Electrician-work	Motor Mechanics	Woodworking
Television and Radiotrician-work	Fitting and Turning	

Each of these subjects has a theoretical and a practical component. In the theoretical part the underlying theory is dealt with. This involves visualizing from orthographic drawings how tools, machine parts or models look like in perspective. Furthermore, the subjects demand varying degrees of mathematical computation, mastering spatial rotations or translations of processes, and lastly also some rote learning. In summary, one can conclude that these subjects lean heavily on both low-level and high-level spatial abilities, but especially on visual processing. i.e. Right brain activity abounds in these subjects.

In the practical part of these subjects the pupils have to apply their theoretical knowledge in order to make three-dimensional models. This involves, once again, calculations, visualizations and algorithmic thinking. This part of the subject serves as an invaluable way towards facilitating the 'handling of 3-D objects'.

Both the theoretical and practical parts of these subjects demand a good command of both rational-linear, logic and methaphoric-intuitive, analogic processes of the mind. That is, an integrated use of the left and right brain is essential to solve the problems in these subjects. However, any lack in right brain ability will be a much more serious disadvantage in technical subjects than in most other 'academic' subjects.

These subjects therefore demand a fair degree of visual processing, as was required in technical drawing. Any lack in this ability will seriously hamper progress. In both technical drawing and technical subjects ample opportunity is therefore allowed for psychomotor development and physical participation. These subjects therefore become part of the pupil's 'lived experience' and hence facilitate meaningful learning.

3.3.1 Mathematical planning by technicians

Matthews(1983) refers to the central role of planning in the field of engineering. He mentions three characteristics common to such tasks:

1. "Choices have to be made and evaluated.
2. There is a requirement to optimise some criterion or criteria.
3. There is an element of uncertainty about the result of the choices which are made."

Matthews(1983) then continues to list some of the areas of mathematics which might be exploited during planning:

1. "averaging
2. numerical progression
3. optimization
4. probability and relative probability
5. two- and three-dimensional shapes and their relationships
6. approximation
7. simple linear programming."

Many of these processes are used in technical subjects and, once again, the propadeutic values of this for tertiary training as technicians or engineers cannot be underestimated.

3.3.2 Management Mathematics

Price(1983) contends that even the technical graduate who is initially hired in his specialist field may find himself in a middle or senior management position later on. In such a position a ".... substantially higher standard of mathematical sophistication is needed ...." After all, this manager has to communicate with his subordinates in both verbal and numerical-symbolic terms. Often statistical reports have to be analysed and important decisions taken on the strength of their results. Managers are accountable and as such they have to be able to quantify variables and to communicate these to both their superiors or subordinates.

3.3.3 Reflexive influences of mathematics and related subjects

The heavy reliance on mathematics by technical drawing and the technical subjects should favour positive attitudes towards mathematics, albeit only to realize its importance. This attitudinal process works both ways and the heuristic value of technical subjects as a way to introduce new topics in mathematics is facilitated. It is expected that pupils would feel that they are not wasting time studying mathematics, that the subject has an immediate use for them.

CHAPTER FOUR.

4.0 AFFECTIVE DOMAIN

Farrel and Farmer(1980) refer to this domain as one with objectives towards "Changes in interest, attitudes, values and the development of appreciation ...."

Most syllabuses contain affective objectives like "cultivating an appreciation for the aesthetic beauty of the subject, realize the importance of the subject in everyday life, enjoyment and interest in the subject" and many more.

How do teachers know whether these objectives have been achieved? Are these objectives evaluated at all? Sad to say, but it seems that this domain has been grossly neglected. This can certainly not be for reasons that it is not important. In the next chapters it will be shown how important the affective domain is towards cognitive-affective- psychomotor interaction and hence towards meaningful learning.

Bell(1978) proposes four reasons why affective learning or at least measurement of it has been neglected.

i. A person's attitudes, beliefs and values are private matters.
ii. There are very few adequate and direct methods to measure affective learning.
iii. Attitudes, beliefs and values are believed to, maybe incorrectly, develop over long periods of time.
iv. Affective objectives are stated in such general terms that it is difficult, if not impossible, to interpret them in any teachable and measurable manner.

4.1 TAXONOMY OF AFFECTIVE EDUCATIONAL OBJECTIVES

David Krathwohl et al (1964) prepared a taxonomy which classified affective objectives into five major categories, with each one containing two or three subcategories. These are(Bell, 1978) :

4.1.1 Receiving

A. Awareness- to be aware of mathematical information and its importance.

B. Willingness to receive - to be willing to learn about mathematics.

C. Controlled or selected attention - to consciously attend to observing and learning mathematics.

Receiving therefore requires only a passive involvement of pupils.

4.1.2 Responding

A. Acquiescence in responding - pupils respond merely to comply or to be obedient.

B. Willingness in responding - pupils have a willingness or desire to respond.

C. Satisfaction in responding - pupils obtain pleasure or enjoyment from responding .

Responding therefore requires active involvement of pupils or 'learning by doing'.

4.1.3 Valuing

A. Acceptance of a value - pupil will value respect and consideration for other people's mathematical hypotheses and arguments (this does not mean that a pupil is committed to that value because it may readily be replaced with a different or contradictory one).

B. Preferring a value - pupils will exhibit a preference for learning mathematics by electing advanced mathematics courses, participate in mathematics clubs, and seek out challenging problems in mathematics (this shows such commitment towards a value that a pupil will want to retain it).

C, Commitment to a value - pupils commit themselves to the study of mathematics by entering mathematics contests, spending much of their free time in mathematical pursuits or major in mathematics (this involves a high degree of certainty to retain a value, a strong reluctance to reject it and even attempts to influence others to accept the same value).

4.1.4 Organization

As values are internalized, situations arise for which more than one value is relevant. Necessity arises for a) organising the values into a system, b) determination of the interrelationship among them, and c) establishing the dominant and pervasive ones. Subcategories of organization:

A. Conceptualization of a value - pupils will determine the basic assumptions underlying the structure of the real number system by discussing these and explaining their value.

B. Organization of a value - pupils will form judgements regarding the positive and negative effects of mathematical and scientific progress upon society by writing a paper about these.

4.1.5 Characterization by a value or value complex

At this stage values are organised into an internally consistent structure, have been held for some time and are firmly established.

Subcategories are:

A. Generalized set - pupils are confident about their ability to learn mathematics and exhibit positive attitudes in class and exert substantial effort in order to master concepts and principles.

B. Characterization - pupils will develop a consistent philosophy of life.

At school level mathematics teachers are more than often so immersed in the cognitive demands of the subject, that the affective objectives are seldom, if ever, remembered.

It is often said that it is not what is 'taught' that counts, but what is 'caught'. What do pupils 'catch' from their teachers? Is it merely compliance? If so, then we have merely managed to achieve the lowest levels of affective learning, and can we expect little if any intrinsic motivation. Then pupils learn merely to please their teachers or parents.

In technical-vocational education this picture can, however, be more positive. In these schools pupils can and should also be motivated when they realize the relevance of mathematics in their other subjects.

In the next chapter it will be attempted to show the implications of the interaction between the cognitive and affective domains.

CHAPTER FIVE

5.0 INTERACTION BETWEEN THE COGNITIVE AND AFFECTIVE DOMAINS.

No study of mathematics learning should concern itself with the cognitive domain only. The affective domain plays an equally important role. This is ironical,because mathematics is one of the most neutral of all subjects, yet it has the reputation of illiciting the most intense negative emotions in pupils. These effects have long been noticed by mathematics educators and have been the subject of many research studies, as important variables towards meaningful learning.

5.1 OVERLAP OF AFFECTIVE AND COGNITIVE TAXONOMIES OF EDUCATIONAL OBJECTIVES

Bell(1978) says: "Although Bloom, Krathwohl and others have structured their taxonomies of educational objectives into two separate taxonomies, cognitive and affective taxonomies, they do not intend to suggest there is a fundamental practical separation between the two sets of objectives." In fact, this overlap is illustrated by Bell(1978) in the following parallel steps:

OBJECTIVES

Cognitive	Affective
1. Knowledge Recall and recognition .	1. Receiving Stimuli received passively .
2. Comprehension Understanding .	2. Responding Willingly respond, self-satisfaction.
3. Application Applies knowledge comprehended .	3. Valuing Responds selectively and voluntarily .
4. Analysis and Synthesis Analysis of situations involving knowledge. Synthesis of this knowledge into new organizations.	4. Conceptualization Conceptualization of each value responded to .
5. Evaluation Judging value of material and methods for given purposes .	5. Organization and characterization Organising values into systems and value complex into a single whole . Characterization of the individual .

Level 1

To learn mathematics (even for purpose of recall) some form of motivation (extrinsic or intrinsic) is necessary. This involves the cultivation of a positive attitude towards the subject.

Level 2

Comprehension involves more than passive reception. Active involvement brings satisfaction and this in itself creates readiness for more involvement and further comprehension.

Level 3

During valuing the pupil learns to appreciate the value of mathematics. This is evident in the cognitive domain as application, where the pupil applies acquired mathematical skills and comprehended knowledge in other situations. In a vocational-technical set-up, this process has the maximum potential to occur when mathematics is used in the other subjects.

Level 4

Cognitive structures are dismantled or assembled while affectively a need for universal criteria is felt in order to structure value systems.

level 5

Cognitive evaluation of knowledge is taking place in terms of internal logic and external criteria, while affective organisation of value systems into a consistent value complex is taking place.

5.2 CAUSAL RELATIONSHIPS.

The question which arises now is whether the cognitive affects the affective or the other way round. Krathwohl et al (1973) says that each "....affective behaviour has a cognitive behaviour counterpart and vice versa."

There seems to be three options available :

i. Each domain is sometimes used as a means to the other, though the more common route is from the cognitive to the affective"(Krathwohl, et al 1973). According to Mellet(1983) this is not a very promising approach.

ii. The second approach agrees that the cognitive and affective domains are mutually reflexive on influence. The problem is, however, that one or the other still has to be activated first(Mellet, 1983).

iii. The third possibility allows for the cognitive and affective objectives to be mastered simultaneously. "In some instances it is impossible to tell whether the affective goal is being used as a means to a cognitive goal or vice versa. It is a chicken and egg proposition.
Perhaps it is fairest to say they are both being sought simultaneously" (Krathwohl et al, 1973).
According to Mellet(1983) this is a relatively safe approach, but not necessarily generally valid. Under certain conditions (eg. the nature of the content and the uniqueness of the learner) the one domain may influence the other. Another time the domains have a reflexive influence on each other. Furthermore, learning is a complex phenonemon and the circumstances under which it takes place may differ from place to place, from time to time and from person to person(Mellet, 1983).

This last approach, however, seems to be the most acceptable, because learning occurs in reflexive ways with all the other psychological activities. The exact interrelationships between the cognitive and affective domains still has to be established(Mellet, 1983).

5.3 COGNITIVE- EMOTIONAL- MOTIVATIONAL MATRIX.

Cognition, emotion and motivation can be found in any learning situation. The relative contribution of each variable towards learning may vary according with the content to be learned, the personality of the learner and many other circumstances.

Scheerer(1954) says in the Handbook of Social Psychology:
"Behaviour may be conceptualized as being embedded in a cognitive-emotional- motivational matrix in which no true separation is possible. No matter how we slice behaviour, the ingredients of motivation- emotion-cognition are present in one order or another."

Of particular significance to mathematics is the emotion part of this matrix. Buxton(1983) refers to this as a paradox "....that a subject free of emotional content and not value-laden, taught with no consideration of emotional response, should in fact produce the strongest negative reaction in the emotional area of any curriculum area." This 'paradox' becomes the problem of the mathematics teacher and those teachers having to use mathematics in other subjects.

5.4 MEANINGFUL LEARNING.

According to Ausubel(1968) "....new content becomes meaningful to the extent that it is substantively (nonarbitrarily) related to ideas already existing in the cognitive structure of the learner"(Farrell and Farmer, 1980). This involves processes of assimilation and accommodation whereby new concepts are first adapted to be incorporated in the mind and then the existing cognitive structures are adapted to allow for this new 'information'. These are sometimes referred to as the 'match-patch' processes.

Meaningful learning is to be contrasted with rote learning wherein "the new content is arbitrarily (nonsubstantively) related to ideas already existing in the cognitive structure of the learner(Ausubel, 1968). Meaningful and rote learning need, however, not form dichotomy. Content often only becomes meaningful after lower order concepts have been learnt by rote.

Meaningful learning and rote learning supplement each other and could be presented as a continuum:

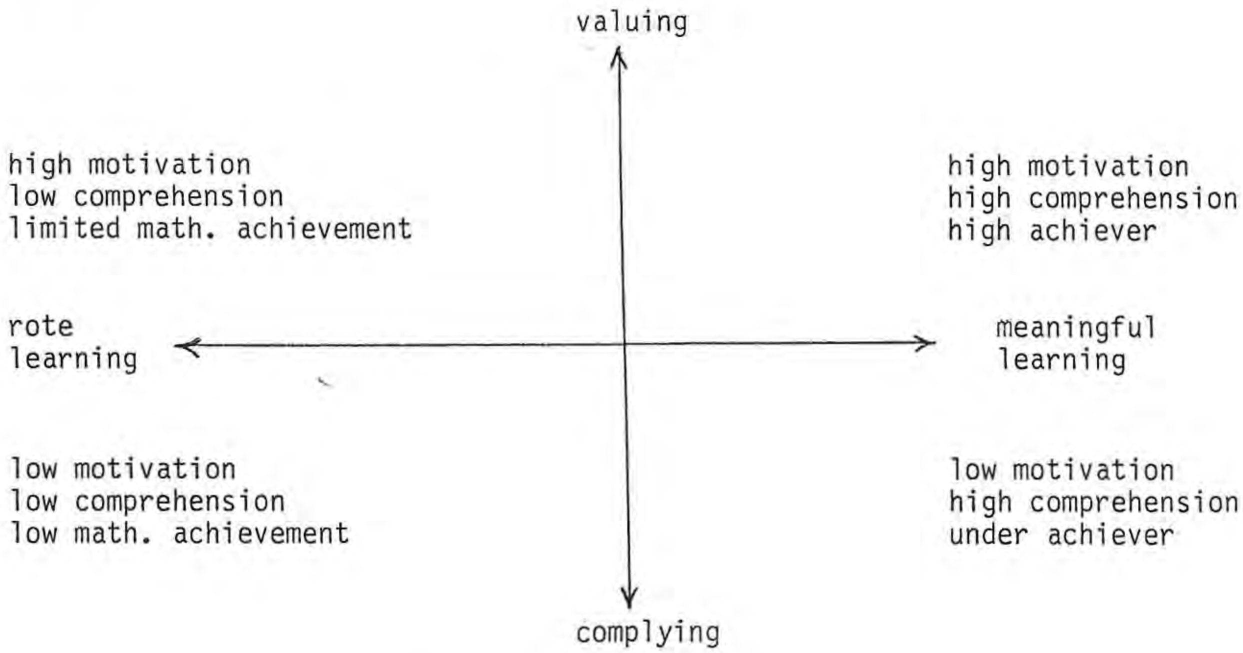
Meaningful learning	Depending on the nature of the content to be learnt	Rote learning
←	———	→

The extent to which learning becomes more meaningful to the learner can, however, be manipulated by the teacher by a variety of teaching techniques.

For the purpose of this study only the motivational-attitudinal aspects will be highlighted.

Teaching the relevance of mathematics can be a powerful tool towards motivation and pupil participation. Pupils must be helped to help themselves. Steffe(1983) says that: "....mathematical knowledge cannot be transferred ready-made from one person to another, but must be built up by the children." This also involves that the mathematics taught should form part of a pupil's lived experience. In a vocational-technical environment, this can come to fruition as pupils use mathematics in their other subjects. At the same time topics in technical subjects may necessitate the mastery of more advanced mathematics and in this way have prodadeutic value in motivating pupils for mathematical content which still has to be covered.

5.5 SCHEMATIC REPRESENTATION OF THE COGNITIVE-AFFECTIVE INTERRELATIONSHIP:



In this chapter an attempt was made to show the intimate relationship between the cognitive and affective variables. Is was pointed out that in a vocational-technical situation, conditions should be ideal for favourable reflexive influences.

CHAPTER SIX.

6.0 TECHNICAL - VOCATIONAL EDUCATION.

6.1 DEFINITIONS.

It is easy to become entangled in the semantics about 'general-academical' education and 'vocational- technical' education. Easier still to be drawn into the debate: "....should general education be the superior aim with vocational education subordinated to it, or vice versa?"(Szaniawski, 1980).

For the purpose of this study vocational-technical education will be considered as education which "....forms the common basis of the professional activity pf employees in (the) manufacturing and service industries"(Szaniawski, 1980). It should, however, be pointed out that 'education' is still involved. This implies that all the general aims of 'academic' education apply to vocational-technical education as well. Example: 'To facilitate the child to achieve self-actualization by optimum cognitive- moral- physical- and spiritual development.'

6.2 Curriculum and examinations (Cape Education Department)

Apart from the non-examination subjects like Bible- and Physical Education, the examination subjects at technical High schools are as follows:

Std. 6 - 7	Std. 8 - 10		
English	English	COMPULSORY SUBJECTS.	
Afrikaans	Afrikaans		
History	-----		
Geography	-----		
Mathematics	Mathematics		
General Science	-----		
-----	Physical Science		
Technical Drawing	Technical Drawing		
Basic Theory and Practice	-----		
	Television and Radiotrician- work	OPTIONS (choose one) PRACTICAL TECHNICAL SUBJECTS	TECHNICAL SUBJECTS
	Electrician-work		
	Fitting and Turning		
	Motor Mechanics		
	Woodworking		
	Welding and Metalworking		
These options are not popular	Motor Body Repairing		
	Plumbing and Sheet Metalworking		
	Bricklaying and Plastering		

The following needs to be noted from this curriculum:

i. Only English and Afrikaans are not mathematical or mathematically related subjects.

ii. The curriculum is rather rigid. The only option available is a choice from one of the technical subjects.

iii. The examinations written at the end of std. ten are the same as those written by pupils in 'ordinary' high schools and the same pass requirements are applicable.

iv. Matriculation Exemption Certificates can be obtained by a suitable choice of subjects/courses.

v. Four of the subjects at senior level (English, Afrikaans, Mathematics and Physical Science) are 'academic' subjects.

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6.3 Myths of technical education and sex-related tendencies in vocational-technical education.

The heavy reliance on mathematics by technical education has already been pointed out. Slow learners, or pupils with below average ability in mathematics may, by choosing his subjects correctly, probably progress further in an ordinary high school than in a technical high school(Rostrum, 1983).

Only 150 marks out of a total of 2100 marks can be gained by manual skills in the practical- technical subjects. Experience, however, showed that it is not the dull, but the bright pupil who excels in the practical subjects(Rostrum, 1983). This seems contrary the popular belief of those who want the dull pupils to take up technical education because 'they are good with their hands'. Why don't 'dull' pupils then excel in the practical part of technical subjects? The answer probably lies in the fact that even the practical part of technical subjects demands a fair degree of high-level spatial ability(visual processing) to interpret technical drawings. It has also been found that below average pupils perform worse in practical subjects and especially poorly in mathematics(Smith, 1975).

Why were there only 25 girls amongst a total population of 6459 pupils in technical high schools during 1983 in the Cape Province?(Rostrum,1983). Does the answer lie in rigid cultural stereotyping of girls into non-technical careers? Or does the reason lie in the tendency for girls to prefer left hand brain activities(verbal logical)? A number of researchers(Noble, 1974; Cockroft, 1982; Badger, 1981) seem to support the notion that boys outperform girls in right hand brain activity (visual-spatial tasks). Further to this is has been pointed out in this study that females and males differ with respect to anxiety (Betz, 1978; Perl, 1979), attribution(Deaux, 1976; Lindquist, 1981), mathematical self-concept(Fennema and Sherman, 1977, 1978; Dowling,1978), and noting the usefulness of the subject(Perl, 1979; Haven, 1971; Hilton and Berglund, 1974). In each instance females seem to reveal attitudes which are rather debilitating towards mathematics learning. Are females therefore cognitively and affectively less suited for technical education? Smith (1973) adds impetus to this argument saying that it has been found that "....below average girls perform better than boys, except in tests where technical aptitude is measured." Further research in this field may produce interesting results.

Mc Callum(1981) argues that left hemisphere abilities (verbal/education) are the most highly prized at school and that this discriminates against those with 'non-verbal intelligence' abilities. (eg. spatial abilities) This means that many teachers do not value these non-verbal abilities, or the career possibilities of these pupils. Mc Callum(1981) ascribes this 'ignorance' amongst teachers to the fact that they generally come from middle class homes where they have little or no contact with technicians or craftsmen. To what extent have many so-called 'non-verbal intelligence' boys already experienced such discrimination, and how has it affected their general attitude towards school?

Rex and Tummer(1975) quotes the De Villiers report (1948) as identifying some of the following problems about vocational education:

i) "It appeared, furthermore, that advice to pupils on the choice of a course of study after standard six frequently applies on a very simple formula indiscriminately, namely that bright pupils should go to provincial high schools and dull pupils to vocational schools."

ii) As long as a principal's position and status is determined by the number of pupils in his school, he will not kindly accept losing pupils to vocational schools.

iii) There is a popular misconception that less intelligent pupils are practically-minded.

It is interesting to note that this report dates back to 1948. How many of these misconceptions about vocational-technical education are still with us? An answer to this is implied by the De Lange report of 1983 which advocates, amongst others, the following:

i) Greater "....balance between general formative preparatory academic education and general formative preparatory career education that is better related to the manpower needs of the country (of course all forms of education lead to careers)."

ii) Curriculum design should be such that the mathematical, natural science and technical (designing and making) development of the learner can get under way from as early an age as possible as a normal part of the process of schooling."

iii) "In view of the well entrenched resistance to this kind of education in the RSA, a well-planned publicity and guidance programme should be embarked upon to place it in the right perspective."

It appears that some of the prejudices and misconceptions about technical-vocational education of 1948 are still with us in 1985.

What about the future of technical education? Rostrum(1983) refers to new courses, Technica: Mechanical, Civil, Electric and Electronic on both HG and SG. "These subjects, together with compulsory Technical Drawing, will give pupils the necessary background for a career as an <u>engineer</u> or <u>technician</u> in one of these fields"(Rostrum,1983). These courses will undoubtedly place heavy cognitive demands on pupils, but those with the necessary aptitude and attitude should be able to cope. These courses will also provide excellent preparation for tertiary studies in engineering at technicons and universities. Lastly, these courses will hopefully uplift the image of technical education.

Sir Anthony Eden (1956) said: "The prizes will not go to the countries with the largest population. Those with the best systems of education will win. Science and technical skill give a dozen men the power to do as much as thousands did fifty years ago. Our scientists are doing brilliant work. But if we are to make full use of what we are learning, we shall need many more scientists, engineers and technicians"(Mc Callum, 1981).

6.4 Aptitude testing for a vocational-technical career.

The De Lange report (1981) refers to "....responsible guidance before deciding on a field of study for the senior secondary phase ....". This places a heavy responsibility upon those offering official guidance to pupils, i.e school psychologists, teachers and parents.

What are the criteria at present? What influences a standard five pupil to decide whether he should attend a technical- or ordinary high school?

To answer the above question, one would probably have to entertain a multitude of factors, too many to be discussed in any detail in this study. Suffice to say that the final decision is suspected to be reached without much scientific thought.

Some of these unscientific factors are suspected to be as follows:

i Peer influence: In each primary school is a 'decision-maker' amongst the pupils whose views are held in high esteem by others. His choice of high school becomes the norm for the others.

ii Parental socio-economic status: Parents send their children to high schools which are regarded to match their own social standing.

iii Parental loyalty: Parents send their children to those high schools which they themselves have attended, or to schools which suit them religiously, politically, etc.

iv High school status: Senior Certificate results, sports results, behaviour and dress of pupils and teachers, social status of past pupils etc.

The only 'scientific-objective' links in the decision making process at present are probably:

i Standard five pupils provide a self-report questionnaire regarding their interests. This, together with a pupil's verbal/non-verbal I.Q. and scholastic achievements, are then used by a school psychologist to advise a technical or ordinary school career.

ii A principal of a technical high school may consider applications from standard five pupils and consider these solely on the basis of the pupil's scholastic achievements.

Both these methods have their shortcomings and there is a real need for a more objective measuring instrument. It is suggested that such a measuring instrument should provide a profile of a pupil showing the followin

i Verbal/non-verbal I.Q.

ii Scholastic achievements (first language, mathematics, general average).

iii Spatial abilities (low and high level).

iv Attitudes towards mathematics (self-confidence, attribution, anxiety and perceived usefulness of mathematics).

v Interest in technology.

vi Attitude to school.

The next chapters will consider the 'attitudes' of pupils empirically in an attempt to provide a profile of the status quo.

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CHAPTER SEVEN.

7.0 RESEARCH DESIGN AND METHODOLOGY.

7.1 Ex post facto research.

Ex post facto research is resorted to in circumstances when the more powerful experimental method cannot be used. That is, when the dependent variable cannot be manipulated for either ethical or practical reasons. The researcher is thus faced with a fact accompli and nothing can be done to provide control and experimental groups. Hence the name 'ex post facto', meaning "....from what is done afterwards"(Cohen and Manion, 1980).

Kerlinger(1970) formally defines ex post facto research "....as that in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables"(Cohen and Manion, 1980).

This particular study will be a co-relational type of ex post facto research. In co-relational studies the antecedents of a current situation are identified. No causal relationships can, however, be claimed, and the variables can therefore not be classified as 'dependent' or 'independent'. One therefore has no control over the variables and one cannot say which causes which.

Furthermore, ex post facto research relies on data from the same source and for this reason hypotheses cannot be tested, but merely illustrated. Cohen and Manion (1980) say that ex post facto designs should rather be regarded as surveys which can provide useful sources for hypotheses to be tested later by conventional experiments.

7.2 Ex post facto in present study.

In this study subjects possess certain attitudes which they have acquired previously(first variable). These attitudes will then be

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related to choice of high school(second variable). The researcher has no control over any of these variables. Attitudes already exist, and by the time this questionnaire in completed, the pupils have already decided which type of high school they wish to attend. Furthermore, causation cannot be claimed, and inferences about whether attitudes to mathematics influence choice of high school, or vice versa, would not be valid.

7.3 Sampling.

Convenience sampling involves using the nearest individuals, usually captive audiences like pupils. This type of sampling was found to be the most suitable for the present study, and all primary schools in East London were invited to partake. The sample was cross-sectional using only standard five boys of English and Afrikaans primary schools. A good response produced 401 completed questionnaires from 12 primary schools.

Neither pupils in the special class nor girls were used in the survey. The reason for excluding these two groups were: i) Pupils from the special class enter special secondary schools and are not considered for entry into technical high schools. ii) Very few, if any, girls ever opt for technical education. Exclusion of these two groups offered a more homogeneous population and hence provided some control in the study.

7.4 Hypotheses.

The following null-hypotheses were entertained:
There is no significant differences between choice of type of high school (technical vs non-technical) and:

i. Anxiety about mathematics.
ii. Self-confidence about mathematics.
iii. Perceived usefulness of mathematics.
iv. Self-reported achievement in mathematics.

v. Peer influence on attitude towards mathematics.

vi. Self-perceived ability in mathematics.

vii. Self-reported general academic achievements.

viii. Liking for school

ix. Liking for and interest in mathematics.

7.5 Measuring attitudes.

The HSRC (1980) distinguish between 'establishing' and 'measuring' attitudes. In the first instance individual items are presented on face value. In the second case constructs are identified by groups of items (eg. anxiety, self-concept etc.). This study will therefore 'measure' attitudes.

Attitudes can be inferred from behaviour, deduced from interviews, or identified from self-report quiestionnaires. Each method has its advantages. The latter has the advantages that a large number of subjects can become involved and it can be done quickly and relatively cheaply. For these reasons it was favoured. Also, Neale(1969) claims that "....a variety of studies indicate a remarkable constant correlation between self-reported attitude towards mathematics, and standardized mathematics achievement test scores."

7.5.1 Validity and reliability.

Van Dalen(1973) says an instrument which measures what it claims to measure is valid.

i. Content validity: Sampling on an attitude domain must cover all aspects of that domain before valid generalizations can be claimed. For example, to generalize about attitudes to school, attitude test items must be representative of all the contributing elements. Furthermore, "....if certain aspects of the school environment are omitted or overemphasized, the instrument will not have satisfactory content validity"(Mitzel, 1982).

ii. Predictive validity: Mitzel(1982) says that "....very high correlations between attitude and behaviour should not be expected; attitude is only one of many factors affecting behaviour." Certain measures can, however, give attitude scales greater predictive validity. For example, when "....attitudinal and behavioural measures show a high degree of correspondence .....", when attitudes are "....measured under high commitment conditions(i.e when subjects thought that they would be performing the behaviours) ....", and when attitude scales have many affective rather than cognitive items(Mitzel, 1982).

iii. Construct Validity: When two or more attitudes are each measured by two or more different methods, (eg. semantic differential measure and partially structured stimuli like incomplete sentences) a measure of the construct validity is obtained(Mitzel, 1980). For this particular study only one method to measure attitudes, self-report questionnaires, is used, and its construct validity can therefore not be assessed.

iv. Reliability: Van Dalen(1973) says a test "....is reliable if it consistently yields the same results when repeated measurements are taken of the same subjects under the same conditions." To ascertain the reliability of this study would produce difficulties: The 'test-retest' method can introduce presensitization and the 'parallel-forms' method cannot be used because "....most attitude scales do not have alternate forms"(Mitzel, 1982). The 'split-half method(Van Dalen, 1973) which divides the test items randomly into halves, seems to be the only way of measuring reliability, or rather internal consistency, in attitude measurement. The reliability of this study was not assessed because the constructs contained too few items.

The factors above merely highlight some of the more 'general' requirements of a measuring instrument. More detailed 'pitfalls' of self-report questionnaires are dealt with in the next section.

7.5.2 Self-report questionnaires.

In measuring attitudes to mathematics, Light(1984) started off with a rather condensed version of a Likert scale, providing for only four responses to each statement(viz. 'dislike very much', 'dislike', 'like' and 'like very much'). He, however, eventually combined the statements into two categories, 'agree' and 'disagree'. In the present study a dichotomy (agree/disagree) was used directly, because it was felt that the topic(feelings towards mathematics, choice of high school) is well-known to the respondents and additional responses like 'uncertain' would have been unnecessary (HSRC, 1984).

To avoid response sets (tendency to agree) Mitzel (1982) suggests the following:

i. Make the purpose of the survey less obvious by including items unrelated to its purpose. In this study it was done by disguising 'technical' high school by offering five different types of high schools(academic, art, commercial, technical and agricultural)

ii. Establish report with respondents and appeal for their honest responses. Allowance was made for this in the covering letter to the invigilators (see annexure 6).

The following suggestions by the HSRC (1984) were considered in the selection of a questionnaire for this study:

i. There should be about an equal number of positive and negative items.

ii. Avoid statements like: 'do you think that most people....' Rather ask what the individual thinks or feels. There may, however be exceptions, like in sensitive cases where a respondent does not want to reveal his feelings. In this study only four such statements were posed.

iii. Avoid the "important" scales in responses(eg. 'important', 'very important').

iv. Separate the statement from the instructions about answering the questionnaire. This avoids long clumsy questions.

v. The statements in postal questionnaires should be as short as possible. Unnecessary words can only raise unwanted emotions.

vi. Avoid leading questions which can influence respondents.

7.5.3 The measuring instrument.

A self-report postal questionnaire was used. This questionnaire was an adapted version of the one proposed by Riedesel and Burns(1977) (Riedesel Inventory of Children's Attitudes towards Mathematics).

This questionnaire was tested and used by Light(1984). Small adaptations were nevertheless made:

i. The responses were reduced to a dichotomy (agree, disagree).

ii. The items regarding teachers, teaching styles and family variables were excluded.

iii. Five statements regarding high school preference were added.

(See annexure 7 for questionnaire)

7.5.4 Subcategories of questionnaire.

	Category/construct	Statement number
i	Anxiety about mathematics	4, 14, 22, 30, 39, 43, 48, 54, 57
ii	Mathematics self-concept	2, 10, 15, 18, 37, 55, 46, 51, 61
iii	Perceived usefulness of mathematics	7, 19, 24, 28, 32, 36, 38, 45, 47, 52, 5
iv	Self-reported achievement in mathematics	12, 25, 41, 44, 77
v	Peer influence on attitudes towards mathematics	78, 79, 80, 81

vi	Self-perceived ability in mathematics	9, 17, 42, 60
vii	Self-reported general academic achievement	73, 74, 75, 76
viii	Liking for school	62, 63, 64, 65, 66, 67, 68, 69, 70, 72
ix	Liking for mathematics	1, 5, 11, 16, 27, 29, 33, 35, 40, 53, 58
x	Interest in mathematics	3, 8, 13, 20, 21, 26, 34, 49, 50
xi	Preference of type of high school	6, 23, 31, 56, 71

7.6 Method.

After obtaining permission from the Cape Education Department to administer the questionnaire, a pilot study was undertaken.

7.6.1 Details of the pilot study.

At the start of the third term a primary school with thirteen English and nine Afrikaans speaking boys participated in the pilot study.

As both the researcher, and the pupils' 'mathematics' teacher may have inhibiting influences on pupils' responses, it was arranged with the headmaster that the invigilator be any other member of staff. The invigilator was then briefed about the purpose of the questionnaire, warned about presensitization of pupils, and requested to allow pupils to freely raise any problems they experience in responding to the statements. The maximum time allowed was 40 minutes.

The invigilator afterwards reported the following:

i. The questionnaire were handed out and the statements dealt with, one at a time. Any queries were cleared and for each statement it was noted how many pupils had difficulties with it.

ii. Very few statements presented problems. The statement referring to'academic' high school produced the most difficulties. The word 'ordinary' high school would have been a better word.

iii. The time limit of 40 minutes was more than adequate.

From the discussion with the invigilator, it appeared that both he and the pupils enjoyed the excercise. Maybe because this was something different from ordinary schoolwork and because it could be done during school hours (departmental permission was granted for this).

The problem with the word 'academic' (statement 71) was not considered serious because the 'technical' alternative (statement 56) appeared earlier in the questionnaire, and no pupil had problems with it. Furthermore, the researcher is convinced that as a result of a publicity campaign earlier in the year, during which all standard five boys visited the local technical high school, they knew the difference between the 'technical' and the 'other' alternatives. This study relates 'technical' with 'non-technical' and confusion about the semantics regarding 'academic' is therefore irrelevant.

In view of the preceding discussions it was decided not to alter the statements in the questionnaire.

Typing the questions on A4 paper necessitated the use of four pages. It was felt that this would scare pupils. The print was therefore reduced and all four pages condensed on one A4 sheet, showing two pages on one side and the other two pages on the reverse side. This also cut printing costs.

7.6.2 The survey.

7.6.2.1 Timing of survey.

Towards the middle of August 17 primary schools in East London were approached for permission to administer the questionnaire to their standard five boys.

It was hoped that pupils would complete the questionnaire early in September, preferably after they had written their terminal examinations and when they knew their academic positions generally and in mathematics. Many primary schools complete their terminal examinations towards the end of August, and for those the timing of the research would be ideal. The pupils in other primary schools should also know their strengths in schoolwork generally, and in mathematics, from their June examinations and subsequent class tests.

Furthermore, Departmental permission was granted for the survey to be administered during school hours. This assisted greatly towards creating a favourable atmosphere towards the study.

7.6.2.2 Standardized conditions.

To standardize the conditions under which the questionnaires would be completed, a covering letter to the invigilator was prepared (annexure 6). This letter contained the same information as the one requesting the principal's permission to perform the research at his school and which the Department approved of. In particular, the invigilator was asked not to presensitize pupils by warning them in advance about the content of the questionnaire. He was also requested to put the boys at ease and to ensure that neither the boys' nor the school's identity be revealed.

7.6.2.3 Choice of invigilator.

To avoid the possible inhibiting effects pupils' mathematics teachers or the researcher may have on pupils, it was suggested that another member of staff would do the invigilating. Class teachers would be ideal because they should have good report with their pupils.

7.6.2.4 Feedback.

Twelve primary schools participated in the survey. A total of 401 pupils were involved, 300 English speaking and 101 Afrikaans speaking.

ANALYSIS OF PARTICIPATING SCHOOLS.

NUMBERS OF PROSPECTIVE TECHNICAL AND NON-TECHNICAL PUPILS.

	ENGLISH (E)		AFRIKAANS (A)	
School	Technical	Non-Technical	Technical	Non-Technical
1			3	
2			7	5
3			4	5
4			1	7
5	8	4	4	1
6			18	38
7	11	14	7	1
8	7	8		
9	19	32		
10	26	34		
11	10	76		
12	10	40		
TOTAL	92	208	44	57

TOTALS : 300 E + 101 A = 401 (E + A)

7.6.2.5 Calculations of Chi-square values.

Chi-square values were first calculated separately for English (E) and Afrikaans (A) speaking pupils and then for the combined scores (E+A) of both groups. A short computer programme was written to facilitate calculations (Annexure 8). This was based on the formula:

$$\chi^2 = \frac{N(ad-bc)^2}{(a+b)(c+d)(a+c)(b+d)}$$

a = Non-technical (NT) agree
b = Technical (T) agree
c = Non-technical disagree
d = Technical disagree
N = a+b+c+d

	Agree	Disagree	Total
Non-technical(NT)	a	c	a+c
Technical(T)	b	d	b+d
TOTAL	a+b	c+d	N

example: statement 5 (Combined E + A)

	Agree	Disagree	Total
NON-TECHNICAL(NT)	176	89	265
TECHNICAL(T)	97	39	136
TOTAL	273	128	401

$$\chi^2 = \frac{401\ (6864 - 8633)^2}{(273)(128)(265)(136)}$$

$$= 1,00$$

In some cases frequencies below 20 were encountered. To allow for continuity in these cases, Yate's correction (Koenker, 1981) was applied using the following formula:

$$\chi^2 = \frac{N(\left| ad - bc \right| - \frac{N}{2})^2}{(a+b)(c+d)(a+c)(b+d)}$$

example : Statement 1 (combined E + A)

	AGREE	DISAGREE	TOTAL
NON-TECHNICAL (NT)	223 (a)	42 (c)	265
TECHNICAL (T)	117 (b)	19 (d)	136
TOTAL	340	61	401

$$\chi^2 = \frac{401\left(\left|4237 - 4914\right| - \frac{401}{2}\right)^2}{(340)(61)(265)(136)}$$

$$= 0{,}12$$

For frequencies below five, chi-square is not valid(Koenker, 1981), and for these no calculations were made. This applied to certain groups of the following statements: 7, 11, 19, 32, 36, 47, 52, 55, 72 (groups = E(NT), E(T), A(NT), A(T)).

Chi-square values were also calculated for constructs (eg. anxiety, self-concept etc.). In these cases the total number of responses for the relevant statements were used. Example: Anxiety (statements 4, 14, 22, 30, 39, 43, 48, 54, 57).

Total scores (E+A) : a (NT) = 1808 (agree)
b (T) = 908 (agree)
c (NT) = 577 (disagree)
d (T) = 316 (disagree)
N = 3609

$$\chi^2 = \frac{3609 \quad (1808)(316) - (908)(577)^{\ 2}}{(2716)(893)(2385)(1224)}$$

$$= 1{,}15$$

For the constructs 'interest in mathematics' and 'liking for mathematics', one calculations was made. That is, these two constructs were considered as a single one. The reason for this decision was that some of the statements could be interpreted as depicting 'liking' or/and 'interest'. To obtain greater content validity it was therefore decided to combine these constructs.

CHAPTER EIGHT.

8.0 RESULTS OF ATTITUDE SURVEY.

A summary of the chi-square values for each statement is given in annexure 7. The following summary shows only those statements for which chi-square values were obtained with significant differences at less than 5% level of probability.

8.1 Table of chi-square values of statements with $p < 0,5$ (df=1)

E = English speaking pupils A = Afrikaans speaking pupils

E+A = Combined Eng.+ Afr.

		χ^2 at various probabilities			
Statement	construct	$0,05 > p > 0,02$	$0,02 > p > 0,01$	$0,01 > p > 0,001$	$p < 0,00$
4	anxiety	4,98 (A+E)			
14	anxiety				14,60(A)
17	ability in maths	4,64 (A)			
20	interest in maths		6,28(E+A)	9,65(E)	
24	usefulness of maths	5,36(A+E)			
25	maths marks			6,80(A)	
42	ability in maths	4,66(A)			
45	usefulness of maths			7,52(E)	
47	usefulness of maths			7,61(A+E)	
50	interest in maths				11,99(A) 14,85 (A+E)
52	usefulness of maths		5,74(E)		
62	liking for school	3,95(E+A)			
65	liking for school		5,67(A)		
67	liking for school	5,15(E)		6,88(A)	
70	liking for school				14,40(E) 11,90 (A+E)
73	general academic achievement	4,20(E+A)			
74	general academic achievement	4,80(E)		6,94(E+A)	
76	general academic achievement	4,38(E+A)			
79	peer pressure		6,52(E+A)	8,67(E)	

8.2 Item analysis.

In the discussion which follows consideration will only be given to the statements listed above. Prospective technical pupils will be referred to as "technical pupils" and prospective non-technical pupils as "others".

Item 4(Anxiety)

"It scares me to take mathematics."
The combined score of English + Afrikaans pupils reveals a difference at the 5% level of probability, showing that technical pupils are more scared to take mathematics than others. This difference is not very significant.

Item 14 (Anxiety)

"It makes me nervous to even think about doing mathematics."
Amongst the Afrikaans speaking pupils a very significant difference at the 0,1% level of probability is revealed. Technical pupils are significantly less nervous about mathematics than other pupils. Amongst English speaking pupils no differences were found.

No further differences in the nine items testing anxiety were found. It would appear therefore that anxiety about mathematics is of little significance between technical and non-technical pupils.

Item 17 (Ability in mathematics)

"I have trouble with some of the terms and symbols used in mathematics."
Amongst the Afrikaans speaking pupils the difference is significant at the 5% level of probability, showing that technical pupils have more difficulties with terms and symbols than others. This difference is not considered to be significant.

Item 20 (Interest in and liking for mathematics)

"I am more interested in mathematics than in most other school subjects."
Amongst English speaking boys the difference is very significant at the 1% level of probability, showing that technical pupils have a greater preference for mathematics than the other pupils. This trend is

repeated in the combined English-Afrikaans group at a 2% level of probability.

Item 24 (Usefulness of mathematics)

"There is very little need for mathematics in most jobs." Whilst neither the Afrikaans nor the English speaking group show significant differences amongst themselves, their combined scores reveal a difference at the 5% level of probability. Technical pupils agree more with this statement than others.

Item 25 (Achievement in mathematics)

"My marks in mathematics have usually been lower than my marks in other school subjects." Amongst Afrikaans speaking pupils there is a significant difference at the 1% level of probability, revealing lower marks in mathematics for technical pupils. This trend is, however, not repeated for the English speaking or combined English-Afrikaans speaking groups.

Of the four items testing 'achievement in mathematics', this is the only one which produced any significant difference, and then only amongst Afrikaans speaking pupils. It would thus seem that mathematics achievement is of no real consequence in choosing the type of high school. This is surprising, because low marks in mathematics was thought to be one of the reasons why pupils prefer technical education.

Item 42 (Ability in mathematics)

"Word problems in mathematics have always been difficult for me". The only group that reveals a significant difference with this item is amongst the Afrikaans speaking pupils. Technical pupils have more difficulties with word problems at the 5% level of probability.

This result is in accordance with that from item 17 where Afrikaans speaking technical pupils also reported difficulties with terminology. Does this indicate problems about verbalizations? Why only amongst the Afrikaans speaking boys then?

Item 45 (Usefulness of mathematics)

"Mathematics helps in science and other subjects".
Only amongst English speaking pupils is the difference significant at a 1% level of probability. Technical pupils seem to think that mathematics is not all that useful in other subjects, as compared with other pupils. This confirms the result in item 24 where the combined English - Afrikaans technical group also saw "little need for mathemtics in most jobs".

Item 47 (Usefulness of mathematics)

"Mathematics is less important than other subjects".
The combined English-Afrikaans group shows a significant difference at a 1% level of probability. As in items 24 and 45, the technical pupils again underscore the importance of mathematics.

Item 50 (Interest in and liking for mathematics)

"I would like to belong to a mathematics club".
In both the English speaking and the combined English-Afrikaans speaking groups very significant differences at the 0,1% level of probability were found. Technical pupils in both the above groups display significantly greater desires to belong to a mathematics club. This result, together with that of item 20, appears to show a greater interest in mathematics amongst technical pupils than amongst others. The results of the rest of the survey support this notion.

Item 52 (Usefulness of mathematics)

"Mathematics is not very important in everyday life".
This item revealed a significant difference at a 2% level of probability, but only amongst English speaking pupils. Technical pupils agree with this statement significantly more than other pupils. This confirms the results in items 24, 45, and 47 where technical pupils also regarded mathematics as not all that important.

These results are surprising. Four of the eleven statements testing "usefulness of mathematics" drew negative attitudes from prospective technical pupils.

.../74

Item 62 (Liking for school)

"I like school very much".
Only the combined English-Afrikaans group shows a significant difference at the 5% level of probability with this item. Technical pupils seem to like school less than others.

Item 65 (Liking for school)

"I have always enjoyed going to school".
Afrikaans speaking pupils show a significant difference at a 2% level of probability. As in item 62 technical pupils reported less enjoyment in going to school.

Item 67 (Liking for school)

"Schoolwork makes me feel worried and confused".
In all three groups significant differences are revealed with this statement: Amongst the English speaking pupils the difference is significant at the 5% level of probability. The same applies to the Afrikaans speaking group with a significance at a 1% level of probability. In the combined English-Afrikaans group the difference is very significant at 0,1% level of probability. In all three cases the technical pupils agree significantly more with this statement than the other pupils.

This result links well with items 62 and 65 where technical pupils reported more dislike in school than others. Does this dislike in school stem from unpleasant feelings of worrying and confusion about schoolwork, as in item 67?

Item 70 (Liking for school)

"I think that school is very dull".
This statement produced very significant differences at 0,1% level of probability for the English speaking and the combined English-Afrikaans speaking groups. Technical pupils agree with this statement significantly more than the other pupils.

This result confirms the notion that technical pupils don't like school as much as their counterparts, as was revealed in items 62, 65 and 67.

Item 73 (General academic achievement)

"My school marks have been unusually high".
Technical pupils (English-Afrikaans combined group) reported less agreement with this statement at a significace level of 5% probability. This result may indicate that technical pupils are either of general academic ability or even below general academic ability. The level of significance is, however, small and further evidence is necessary before inferences can be drawn.

Item 74 (General academic achievement)

"I do better than most of the pupils in my school".
Amongst both English speaking and the combined English-Afrikaans speaking groups significant differences were revealed at respectively the 5% and 1% levels of probabilities. In each instance technical pupils reported lower general academic achievements than other pupils.

This result now confirms that of item 73 where technical pupils also reported lower general academic achievement than others.

Item 76 (General academic achievement)

"Most of the pupils in my class know more than I do".
The difference between the combined English-Afrikaans technical and the other combined group in this item is significant at a 5% level of probability. Technical pupils reported that others know more than they do, thereby confirming the results in items 73 and 74.

Three of the four items testing 'general academic achievement' show that technical pupils' marks are lower than those of the others.

.../76

Item 79 (Peer pressure)

"Most of my friends don't do well in mathematics".
Technical pupils agree significantly more with this statement than other pupils. This is revealed amongst English speaking pupils at a significance level of 1% probability. Also in the combined English-Afrikaans group a significant difference at the 2% level of probabilty was found.

This result seems to indicate amongst technical pupils peer influences which could inhibit good performances in mathematics. The rest of this survey does, however, not confirm such an inference.

8.3 Analysis of constructs.

A summary of chi-square values for nine constructs is given in the table hereunder. Note that 'interest in mathematics' and 'liking for mathematics' were combined into a single construct. The reason for this was provided earlier.

8.3.1 Table of chi-square values for constructs.

Construct	Number of items	Afrikaans	English	Afr.+Eng
1. Anxiety about maths	9	0,11	0,73	1,15
2. Self-confidence about maths	9	0,61	0,52	0,001
3. Perceived usefulness of maths	11	2,26	8,91**	11,94*
4. Self-reported achievement in maths	5	2,04	1,87	0,34
5. Peer influence on attitude towards maths	4	0,48	0,93	0,06
6. Self perceived ability in maths	4	0,99	0,54	0,05
7. Self-reported general academic achievement	4	4,82****	9,38**	17,36*
8. Liking for school	10	13,03*	8,53**	17,59*
9. Interest & liking for maths	20	2,02	12,58*	6,54**

(See annexure 9 for raw scores)

p < 0,001 * 0,01 > p > 0,001 ** 0,02 > p > 0,01 *** 0,05 > p > 0,0 ****

8.3.2 Discussion of constructs showing significant differences.

Perceived usefulness of mathematics.

A very significant difference at the 0,1% level of probability is shown between technical and other pupils with respect to this construct.

THE NULL-HYPOTHESIS THAT THERE IS NO SIGNIFICANT DIFFERENCE BETWEEN CHOICE OF TYPE OF HIGH SCHOOL (TECHNICAL VZ NON-TECHNICAL) AND PERCEIVED USEFULNESS OF MATHEMATICS IS THEREFORE REJECTED.

Technical pupils in the English speaking group and in the combined English-Afrikaans group reveal a significantly lower appreciation for use of mathematics than their non-technical counterparts. After the item analysis was done, this result is not surprising. What is surprising, though, is that prospective technical pupils see less use for mathematics than other pupils do. This is ironical. How can future technicians and engineers underrate the cornerstone (i.e. mathematics) of technology?

Afrikaans technical pupils, however, rate the usefulness of mathematics as high as their non-technical counterparts.

General academic achievement.

In this construct highly significant differences were found between technical and non-technical pupils. Amongst the Afrikaans group, technical pupils reported lower academic achievement at a significance level of 5% probability. The same trend is repeated amongst the English group with a significance level of 1% probability. The trend is finally established in the combined English-Afrikaans group with a level of significance at less than 0,1% probability.

Of interest here is that amongst Afrikaans technical pupils the level of significance was only at the 5% probability. This shows doubtful significance. In the previous construct Afrikaans technical pupils also showed no difference to their non-technical counterparts with respect to 'usefulness of mathematics'.

Liking for school.

This construct produce highly significant differences between the technical and non-technical groups. Amongst the Afrikaans pupils the difference is significant at a 0,1% 'hevel of probability. Amongst the English pupils this difference is signicant at the 1% level of probability. The combined English-Afrikaans group revealed the highest significant difference at less than 0,1% probability.

THE NULL-HYPOTHESIS THAT THERE IS NO DIFFERENCE BETWEEN CHOICE OF TYPE OF HIGH SCHOOL (TECHNICAL VZ NON-TECHNICAL) AND LIKING FOR SCHOOL IS THEREFORE REJECTED.

In every group (i.e. Afrikaans, English and combined English-Afrikaans) the technical pupils show less liking for school than the non-technical pupils. This construct is the only one which produced significant differences at less than 1% level of probability for every group(i.e. E, A, E + A). These results are therefore consistent throughout the cross section of the population and warrant special comment.

Is this relatively low liking for school amongst technical pupils associated with their frustrations with schoolwork which is predominantly verbal-logical (left hand brain activity)? They probably excel in right hand brain activities (eg. spatial tasks) but receive little credit for it, because they are trapped in an educational system where most of the prizes go to those who can verbalize the best. These pupils, who probably have below average I.Q.(verb), crave for a school system where "other criteria" are valued. They probably see this in technical education where visual-spatial tasks are in greater abundance and where their lower verbalising abilities will hopefully not be penalised as much as in ordinary high schools.
Further research is necessary to investigate this notion.

Interest and liking for mathematics.

This construct provide differing results from the various groups. Amongst the Afrikaans pupils no significant difference was found between the technical and non-technical pupils. Amongst the English pupils this same difference is highly significant at less than 0,1% level of probability, with technical pupils showing more interest and liking for mathematics. In the combined English-Afrikaans group this trend is repeated, but at a much diminished significance of slightly above 1% level of probability. The difference to 1% probability is only 0,1 (6,64-6,54 at df =1). For practical purposes a significance of 1% level of probability will thus be assumed.

THE NULL-HYPOTHESIS THAT THERE IS NO DIFFERENCE BETWEEN CHOICE OF TYPE OF HIGH SCHOOL (TECHNICAL VZ NON-TECHNICAL) AND LIKING-INTEREST IN MATHEMATICS IS THEREFORE REJECTED.

The positive trend referred to earlier with respect to Afrikaans technical pupils is not repeated in this construct. In fact, only the Afrikaans technical group does not show significantly more liking and interest in mathematics.

The results of this construct seems to be at variance with "perceived usefulness of mathematics": The technical group shows greater interest and liking for mathematics, but sees less use for the subject than non-technical pupils.

A possible explanation for this apparent conflicting results may be as follows: In the primary school curriculum, most of the subjects demand a fair degree of recall. Mathematics deviates from this pattern, necessitating more right hand brain activity (eg. in geometry). For prospective technical pupils this is appealing, especially since their left hand brain (eg. verbalization) may be under par with their non-technical counterparts. From this then their greater interest in mathematics.

.../80

The reason for the prospective technical pupils seeing less use for mathematics, in spite of showing more interest in it, is a surprising result. There must be other variables which are not covered by this study, and which are at stake to explain this apparent paradox. One can speculate about this at length, but only further studies may reveal anything worthwhile.

The following null-hypotheses are accepted:

There is no difference between choice of type of high school(technical and non-technical and :

i. Anxiety about mathematics.
ii Self-confidence about mathematics.
iii. Self-reported achievement in mathematics.
iv. Peer influence on attitude towards mathematics.
v. Self-perceived ability in mathematics.

Of interest here is that all but one of the null-hypotheses about mathematics are accepted. Only 'interested in and liking for mathematics' produced a significant difference. It appears that the difference between prospective technical and non-technical pupils has surprisingly little to do with their attitude towards mathematics. The differences appear to be more widely; 'liking for school' or 'general academic achievement'.

CHAPTER NINE.

9.0 SUMMARY AND CONCLUSIONS.

9.1 The problem.

Originally the problem posed was that many pupils who are "good with their hands" report for technical education; that these pupils' mathematics marks are relatively low and their attitudes towards the subject suspect.

9.2 Procedures applied.

A self-report questionnaire was used to identify:

a) certain attitudes to mathematics
b) mathematics achievement
c) general academic achievement
d) preference for type of high school (technical or non-technical)
e) attitude to school

Standard five boys from 12 East London primary schools participated in the study. Of the 401 pupils involved, 265 were English speaking and 136 Afrikaans speaking.

The results from the survey were subjected to chi-square testing. Items and groups of items (constructs) with probability levels of less than 5% were then further examined.

9.3 Findings of the survey.

It was found that the predominant difference between prospective technical and non-technical pupils was not as much related to attitudes to "mathematics", as it was related to school marks in general and unfavourable attitudes towards "school".

The initial suspect areas about attitudes to mathematics and mathematics achievement were not borne out by this study. The problem lies much deeper than mathematics; it is school itself!

Not surprising that Freudenthal(1983) says:

"....all major problems of mathematics education are problems of education as such. In another sense it is exactly right: if you look for major problems the best paradigm of cognitive education is mathematics."

9.4 Limitations of this survey.

It must be stressed that these results apply only to standard five boys in East London. No generalization to other pupils and in other areas are claimed.

The result of the survey were not controlled by another independent method. It must therefore be admitted that construct validity may be under suspicion.

9.5 Suggestions for further research.

Many problems in this study remain unanswered. The initial hope to contribute towards a profile of the "ideal" prospective technical pupil did not materialise. Further researchers may profitably explore this vast area.

Some intriguing questions:

Why do prospective technical pupils underscore the usefulness of mathematics in comparison with prospective non-technical pupils? Does this trend continue throughout high school? How will these same pupils rate the usefulness of mathematics after three years of schooling at technical and other high schools? Will the trend then be reversed with the technical pupils rating the usefulness of mathematics higher than other pupils?

Why do prospective technical pupils have relatively unfavourable attitudes towards school in general? Does this stem from left hand brain dominance at primary school which discriminates against pupils with lower verbal abilities? Further empirical research in this area may reveal interesting results.

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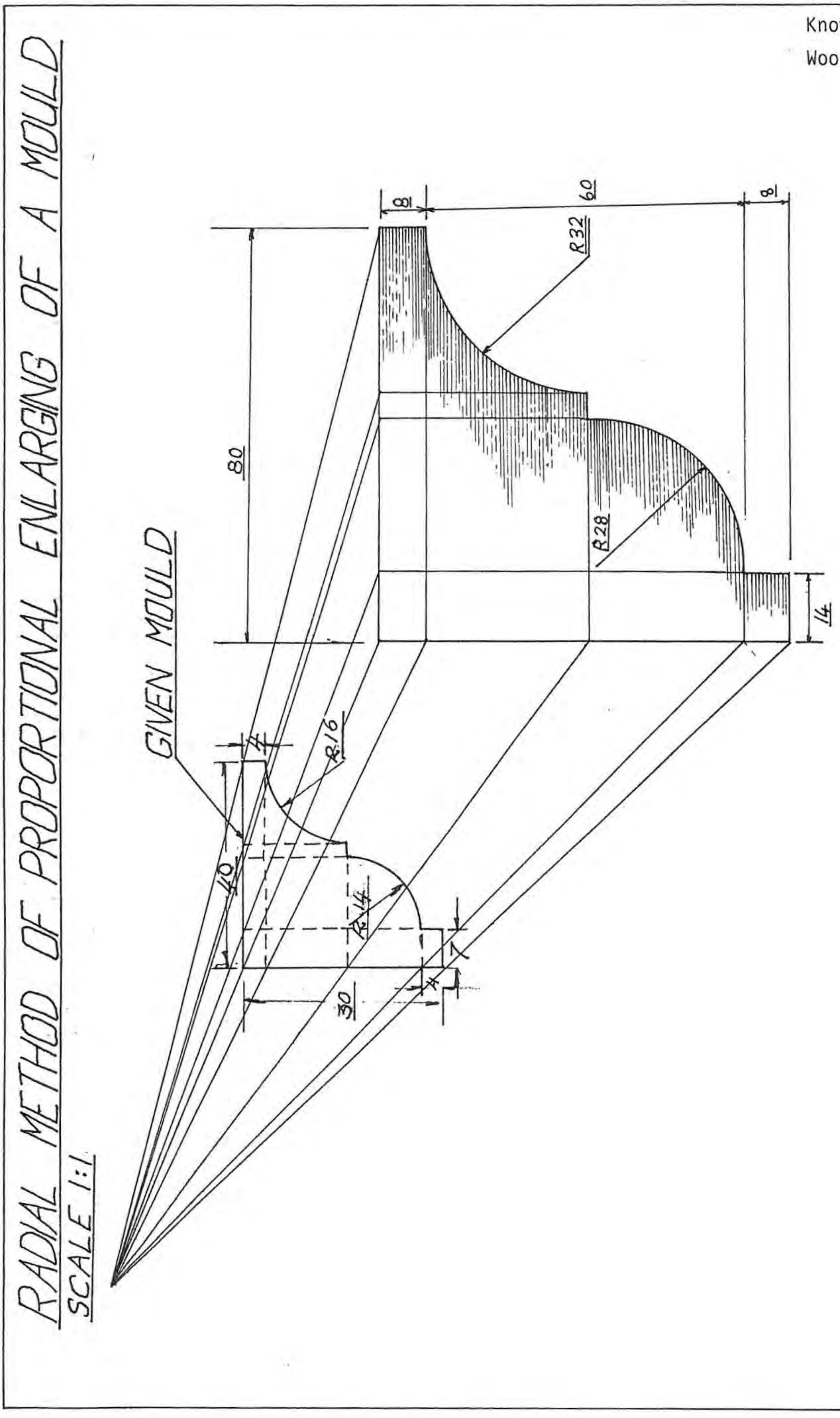
ANNEXURE 1.

Knowledge

Woodworking



ANNEXURE 1.

Knowledge - Techical Drawing (Std. 6 and 7).

Question: Use geometrical methods to construct the figure as follows.

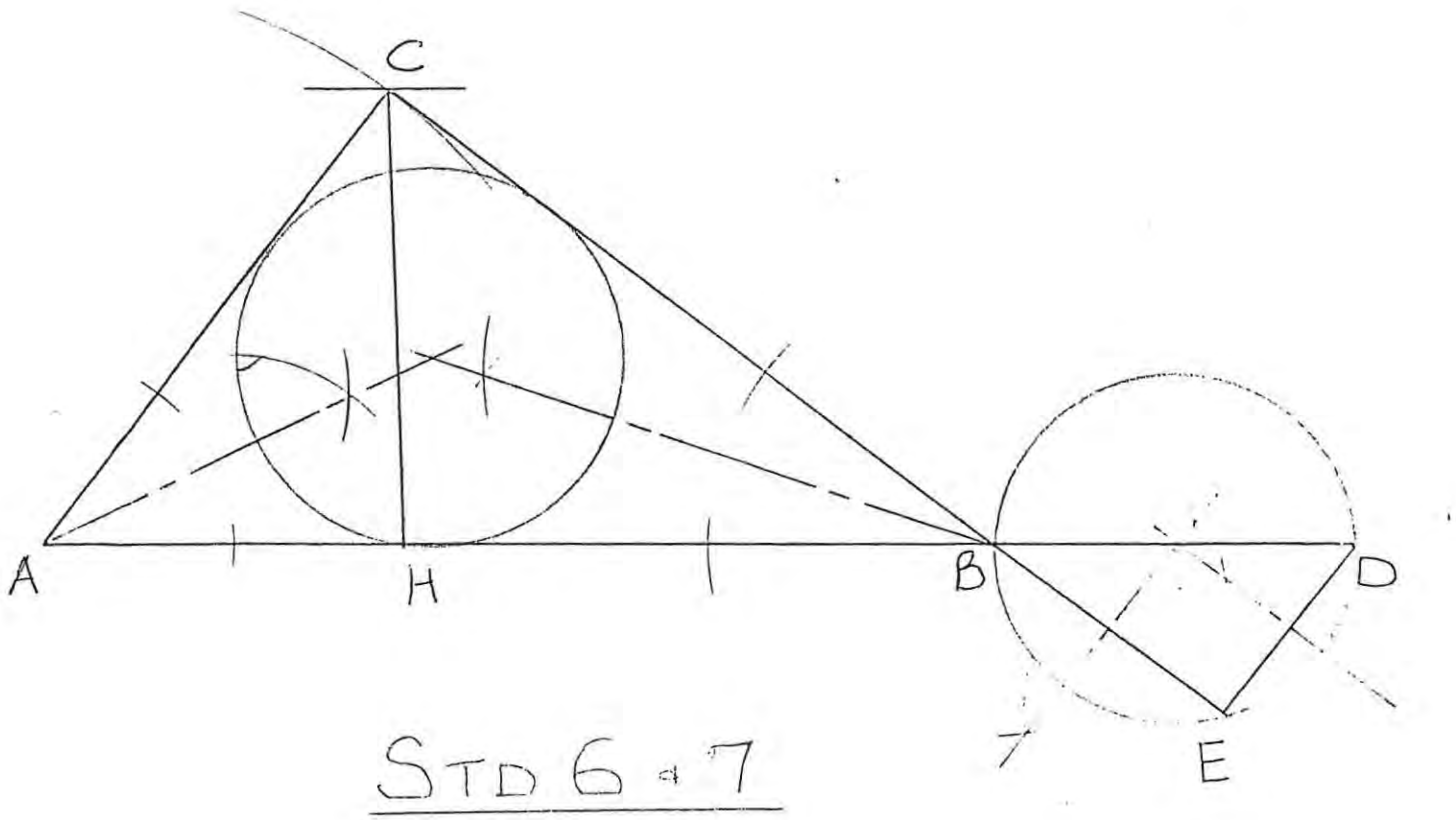
(1) Draw $\overline{AD}$ = 170mm

(ii) Construct the △ ABC with $\overline{AC}$ = 75mm and $\overline{CH}$ = 60mm

(III) Construct the △ BDE with $\overline{ED}$ a perpendicular on $\overline{CE}$

(IV) Draw an inscribed circle in △ ABC

(V) Construct an escribed circle on △ BDE



ANNEXURE 2

Comprehension
TV and Radiotricians
(Std. 10)

Design of Resonant Circuits.

A circuit will resonate when $X_L = X_C$ where $X_L = 2\pi Lf$ and $X_C = \frac{1}{2\pi Cf}$

X_C decreases with frequency while X_L increases with frequency.

The resonant frequency is calculated from the formula $f = \frac{1}{2\pi\sqrt{LC}}$

If the designer is required to design a circuit for (say) 1 MHz* and is restricted to one size of capacitor (say 100pF) then he has no option but to use a 250 nH inductor.

But if the values of both the capacitor and the inductor were left open-ended, and the resonant frequency were fixed at (say) 1MHz, the designer would be given the freedom to interpolate between the following limits:

Inductance : 100 mH to 1 nH

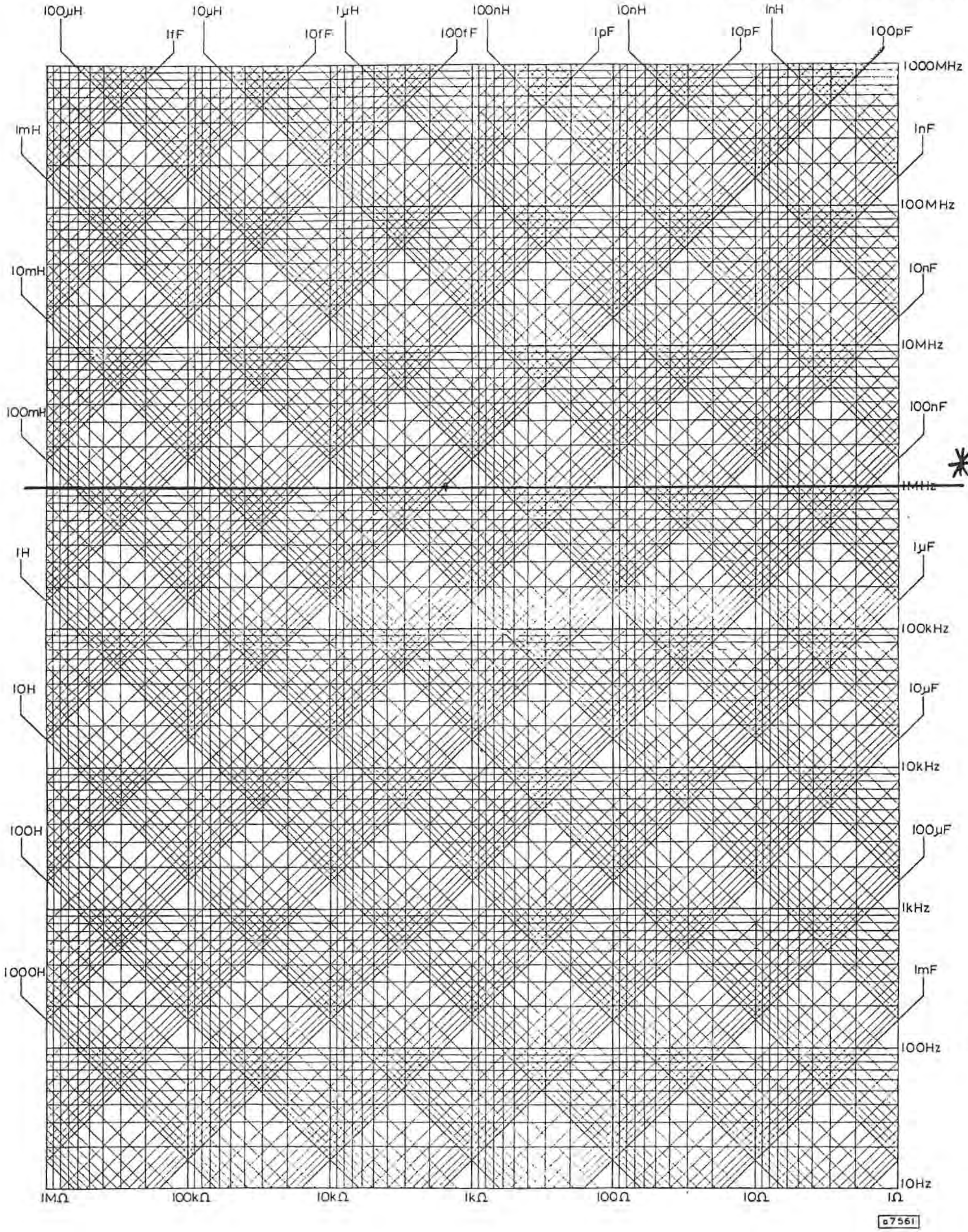
Capacitance : 100 nF to 1 femtofarad.

EXTRAPOLATION A frequency of 1 MHz was chosen in the example. A study of the graph (next page) will show that:

(a) For higher frequencies lower values of C and L must be chosen.

(b) For lower frequencies, higher values of C and L are necessary in order to remain within the limits of the criteria for design.

ANNEXURE 2 (TV and
(Comprehension) Radiotricia



ANNEXURE 2.

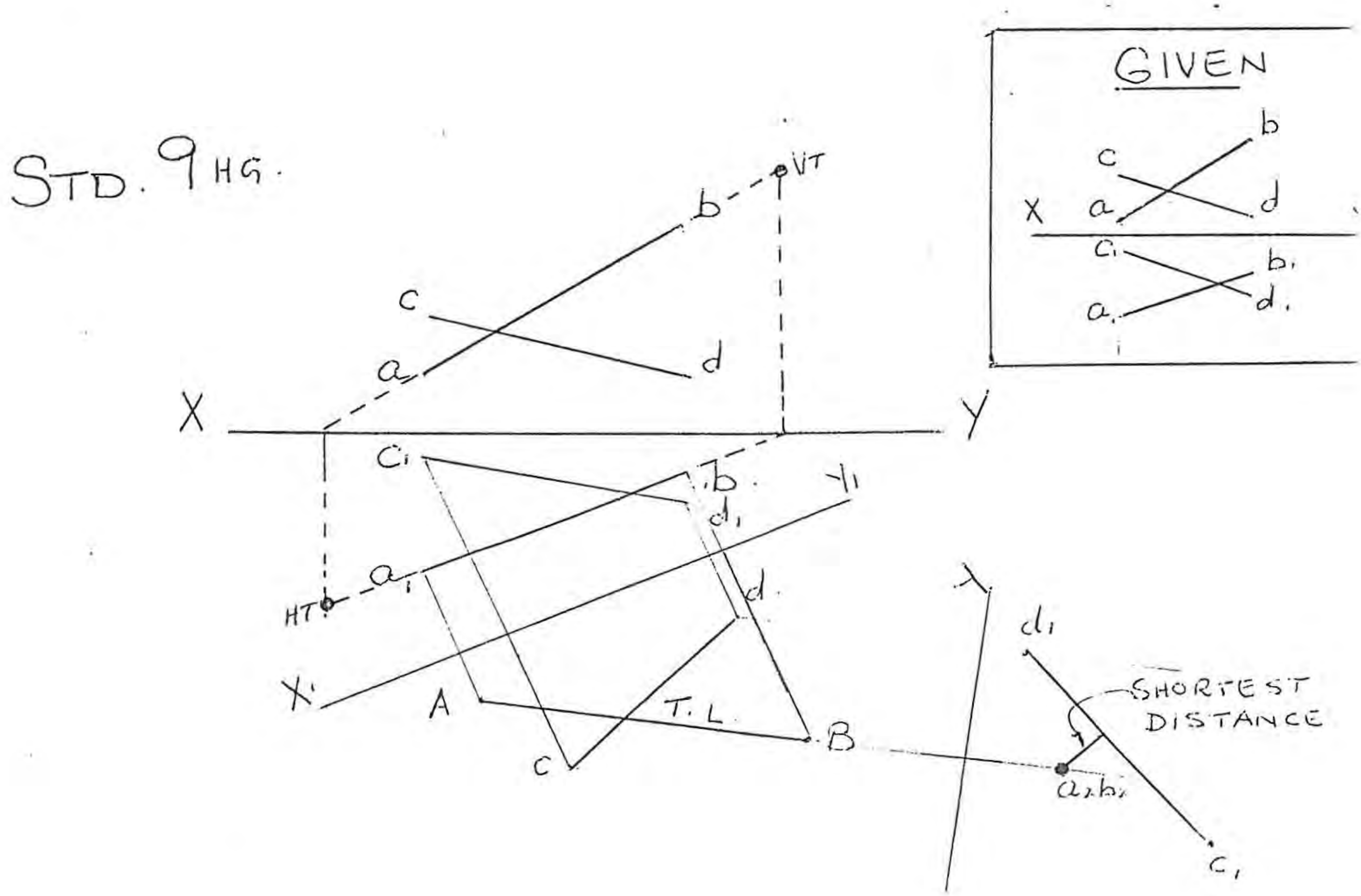
Comprehension (Technical Drawing - Std. 9)

Question: The figure shows the front and top view of the two lines AB and CD. The lines are both inclined to the horizontal and vertical planes.
Copy these views full size and determine by construction and measurement

(I) The true length of $\overline{AB}$.

(II) The shortest distance between $\overline{AB}$ and $\overline{CD}$.

(III) The traces, VT and HT of $\overline{AB}$.



ANNEXURE 3.

Application:

Mathematics: Construct two triangles which are similar but which are not congruent (Std. 9).

Physical Science: A steel cylinder of capacity $1500 cm^3$ is filled with air at S.T.P. Calculate the pressure in the cylinder if $300\ cm^3$ air at a temperature of 27^oC and a pressure of 150kPa is pumped into this cylinder (Std. 10).

Fitting and Turning: (Std. 10)

Example: A square bar 20 mm is subjected to a tensile load of 28 kN.
Determine: (a) the working stress in the material,
(b) the factor of safety if the ultimate stress is 400 MPa,
(c) the extension in mm if the length of the bar is 6 m.
Assume E = 210 GPa.

(a) To find the area

$$\text{Area} = \frac{20 \times 20\ m^2}{10^6} = \frac{400}{10^6}\ m^2 = 0{,}0004\ m^2$$

To find the working stress

$$\text{Working stress} = \frac{\text{Load}}{\text{Area}} = \frac{28 \times 10^3}{0{,}0004} = \frac{280000 \times 10^3}{4}\ \text{Pa}$$

$$\text{Working stress} = 70 \times 10^6\ \text{Pa} = 70\ \text{MPa}$$

(b) To find the factor of safety

$$\text{Factor of safety} = \frac{\text{Ultimate stress}}{\text{Working stress}} = \frac{400}{70} = 5{,}7$$

(c) To find the strain

$$\text{Strain} = \frac{\text{Working stress}}{E} = \frac{70 \times 10^6}{210 \times 10^9} = \frac{1}{3 \times 10^3}$$

To find the extension

$$\text{Extension} = \text{Orig. length} \times \text{strain} = \frac{6 \times 10^3 \times 1}{3 \times 10^3}$$

Extension = 2 mm

ANNEXURE 3.

Application.

Technical Drawing.

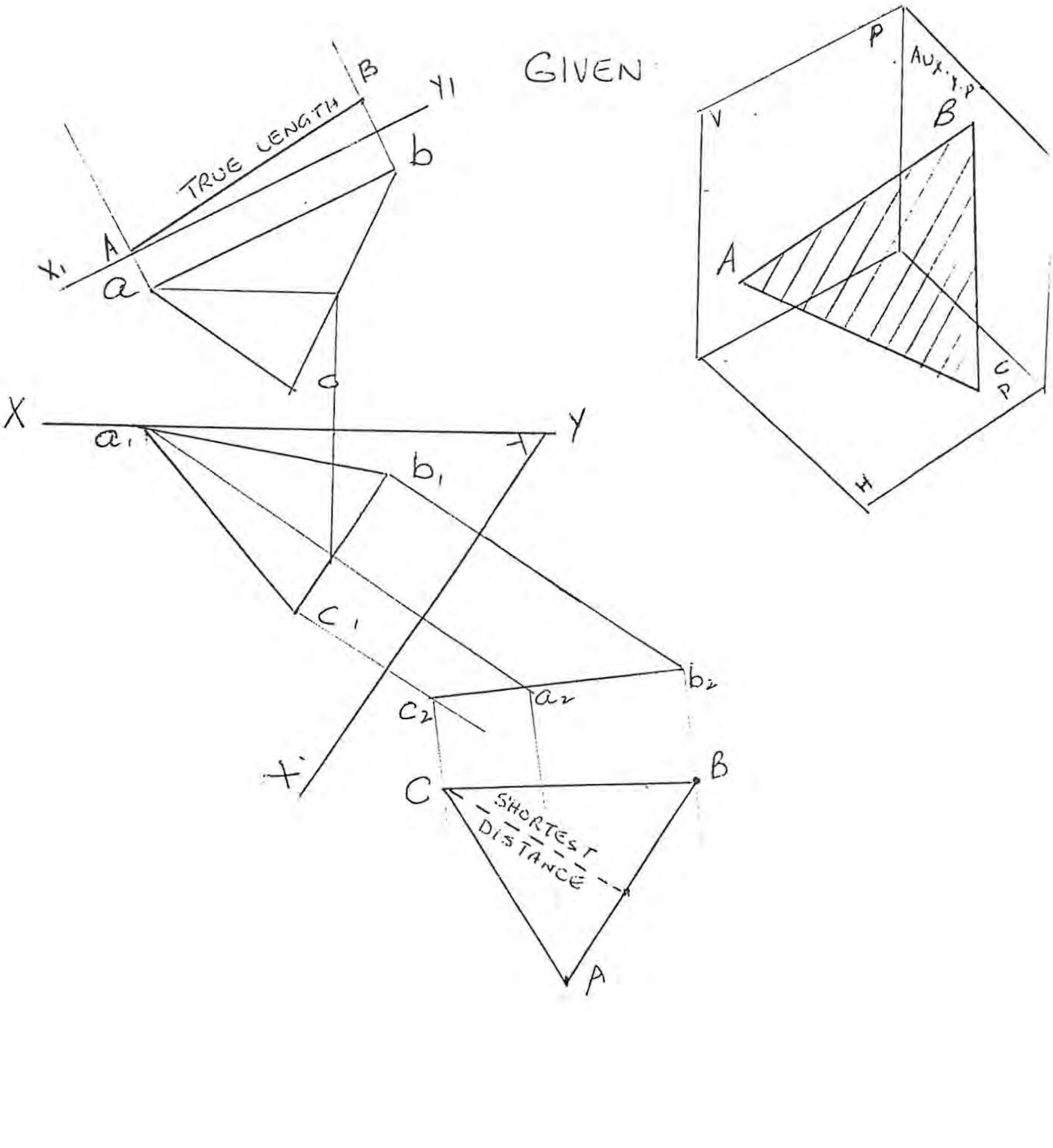
Question.

The figure shows an isometric view of a triangular lamina placed in a box. Use the information given to draw front and top views of the lamina.

Determine by construction and measuring:

(I) The true length of side AB.

(II) The shortest distance between C and $\overline{AB}$.



ANNEXURE 4.

ANALYSIS AND SYNTHESIS.

Mathematics: i) Derive the quadratic formula (std. 10)
ii) In the same circle, prove that equal chords are equidistant from the centre (std. 8).

Physical Science:

Example:

For the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

the value of the equilibrium constant(K_c) is 66,9 at a temperature of 350^oC. If at equilibrium the concentration of both H_2 and I_2 are $3,8 \times 10^{-2}$ $mol.dm^{-3}$, calculate the concentration of the HI in the equilibrium mixture at 350^oC.

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

$$[HI]^2 = K_c \times [H_2][I_2]$$

$$= 66,9 \times 3,8 \times 10^{-2} mol.dm^{-3} \times 3,8 \times 10^{-2} mol.dm^{-3}$$

$$= 966 \times 10^{-4} mol^2.dm^{-6}$$

$$[HI] = 31,1 \times 10^{-2} mol.dm^{-3}$$

ANNEXURE 4.

MOTOR MECHANICS (std. 10)

Analysis and synthesis.

Calculate the indicated power in kW of a four-cylinder four-stroke engine with an engine capacity of 2 litre at a rotational frequency of 3000 r/min and a mean effective pressure of 800 kPa.

$IP = pLANn \quad (W)$

Where $p = 800$ kPa

$= 800 \times 10^3$ Pa

$L \times A = \frac{2000}{4}\ cm^3$ / cylinder.

$= 500\ cm^3$

$= \frac{500}{10^6}\ m^3$

$N = \frac{r/min}{2 \times 60}$ s/s

$= \frac{3000}{2 \times 60}$ s/s

$= 25$ s/s

$n = 4$

$IP = \frac{800 \times 10^3 \times 500 \times 25 \times 4}{10^6}$ W

$= 40000$ W

$= 40$ kW

Note:

Where IP = indicated power.

p = m.e.p. in Pa

L = stroke length in m.

A = Area of cylinder in m^2

$N = \frac{r/min}{2X60}$ working strokes /s

n = No of cylinders

Normally L and A are given in mm which is simply brought to meters and m^2 respectively. But now L and A are not given but L X A (Which is the swept volume of one cylinder) can be derived from:

$L \times A = \frac{\text{Engine capacity}}{\text{No.of cylinders}}\ cm^3$ which must be brought to m^3.

The L X A and the changing of cm^3 would be new to the students.

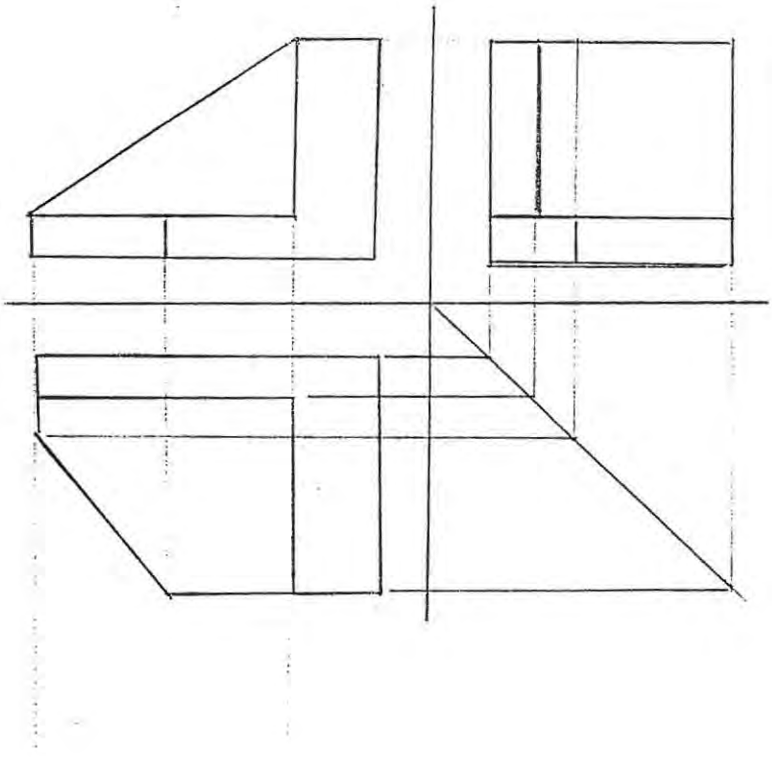
ANNEXURE 4.

Technical Drawing.

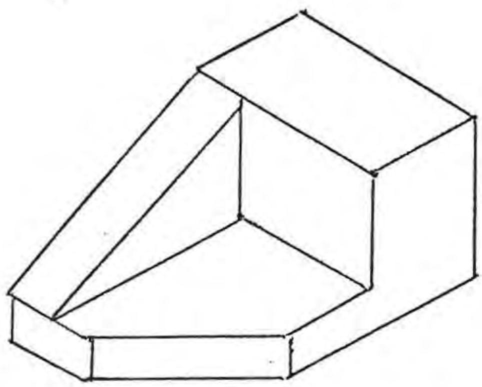
Analysis and Synthesis (Std. 7)

Question.

The figure shows three views of a model in first angle orthographic projection.
Do not copy these views but draw full size an isometric view of the model.



QUESTION



SOLUTION

ANNEXURE 5.

EVALUATION.

Mathematics:

Find the square root of 6342,173 using each of two methods that were presented in class. Compare the two methods and discuss the advantages and disadvantages of each method (Bell, 1978).

Physical Science:

Given the reaction :

$$Cr_2O_7^{2-} + H_2S \rightleftharpoons Cr^{3+} + S$$

Balance this reaction by the Oxidation number method and by the Ion-Electron Method. Compare these two methods now.

Electricians-work (std. 7)

A four ohm, a three ohm and a six ohm resistor are connected in parallel to a 12 volt supply.

Calculate:

a) (i) the total resistance of the circuit, and from this
 (ii) the total current in the circuit.

b) Calculate the total current in the circuit by calculating the current in each resistor first.

c) Compare method (a) and method (b) for calculating the total current in the circuit.

Total resistance in mho $\frac{1}{R_T} = \frac{1}{R_I} + \frac{1}{R_2} + \frac{1}{R_3}$

$= 1/4 + 1/3 + 1/6$

$= \frac{3 + 4 + 2}{12}$

$= \frac{9}{12}$ mho

Total resistance in ohms $R_T = \frac{9}{12}$

$= 1\frac{1}{3}$ ohms

Method (a)

Current in circuit $I_T = \frac{V}{R_T}$

$= \frac{12}{1\frac{1}{3}}$

$= 10 \times \frac{9}{12}$

$= 9$ amperes

Method (b)

Current in R_I, $I_1 = \frac{V}{R_1} = \frac{12}{4} = 3A$

Current in R_2, $I_2 = \frac{V}{R_2} = \frac{12}{3} = 4A$

Current in R_3, $I_3 = \frac{V}{R3} = \frac{12}{6} = 2A$

Total current $I_T = I_1 + I_2 + I_3$

$= 3 + 4 + 2$

$= 9$ amperes

ANNEXURE 5.

EVALUATION.

Technical Drawing. (Std. 8-10)

"the location of oblique line segments in space. True angle(slope) and true length."

The figures show two methods that may be used.

Method 1: (Cone Generator method)

Has definite limitations as it excludes the Auxiliary planes. The latter constitutes a large part of the std. 8-10 syllabi.

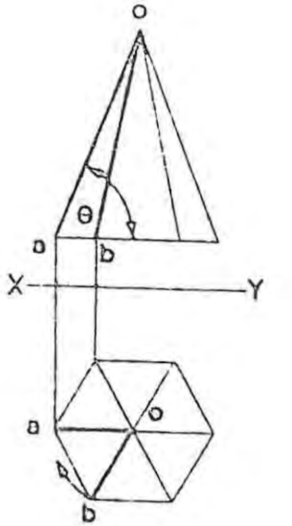
Method 2: (Auxiliary Projection Method)

This method is widely used to determine true lengths; angles etc. It is also used to determine distances between lines, between lines and points; between points and planes etc. A definite improvement on method I.

"Compare the Cone Generator Method with the Auxiliary method."

(Answer on page 96)

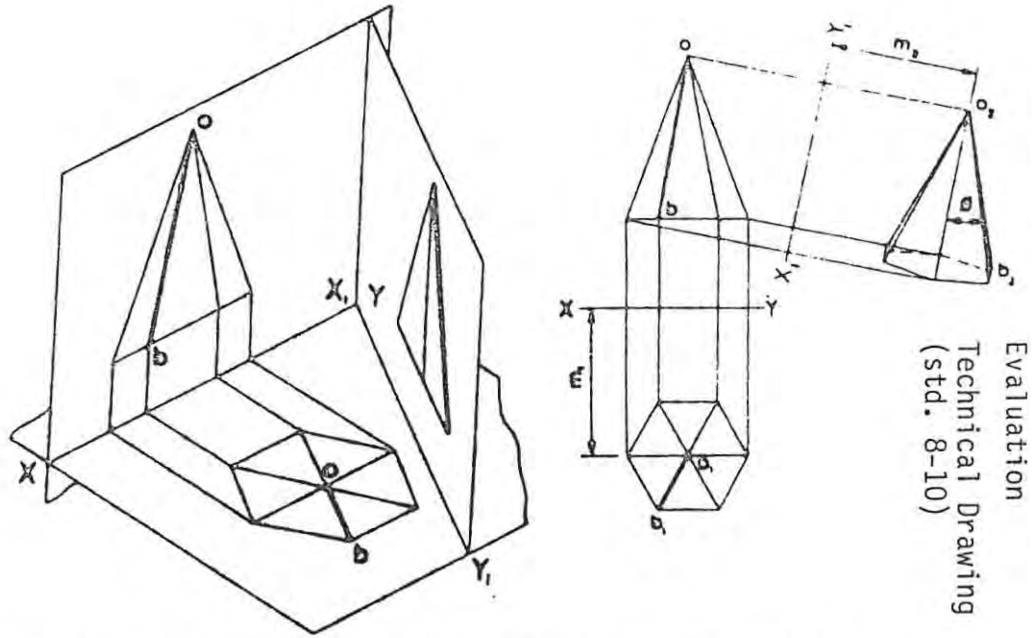
Method 1 Construction method (cone generator method)



Step 1 With centre O_1, draw an arc in the top view and transfer point b_1 to point a_1 as shown.

Step 2 Looking at the front view, $\overline{ob}$ in its new position falls onto $\overline{oa}$; therefore measure $\overline{oa}$ as the *true length* of $\overline{ob}$ and angle Θ as the slope with the horizontal plane.

Method 2 Auxiliary projection method



Step 1 Draw the given views in first angle orthographic projection.

Step 2 Draw X_1Y_1 to represent the inclined plane parallel to the *top view* $\overline{o_1b_1}$.

Step 3 Apply the rule of similarity ($n_1=n_2$).

Step 4
- Measure the length of $\overline{o_2b_2}$ = true length of $\overline{OB}$.
- Measure angle Θ = slope of $\overline{OB}$ with the

ANNEXURE 6.

RESEARCH PROJECT : "ATTITUDES TOWARDS MATHEMATICS/TYPE OF HIGH SCHOOL CHOIC

NOTICE TO INVIGILATORS.

Dear Colleague

A Thank you for assisting in this research project.
Please avoid presensitization. Do not warn pupils in advance about the content of the questionnaire.
There is nothing contentious about the content of the questionnaire and it will not reflect in any way on schools and teachers.
Please do not identify the researcher.
A franked envelope is included for returning the questionnaires.

B PLEASE READ THE FOLLOWING TO THE BOYS JUST BEFORE THEY COMPLETE THE QUESTIONNAIRE.

1. This is not a test to find out how much you know about your schoolwork. Please feel at ease. We simply want to know how you feel about certain matters. You simply have to mark one block with a cross each time. You either agree or disagree with the statement.

2. Do not write down your name or that of your class or school anywhere. Please be honest and give only your own opinion about matters.

3. No questions about your parents or your teachers are asked.

4. Read the statements carefully. Some of them are very similar.

5. Maximum time allowed : 40 minutes.

Thank you for your co-operation.

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

A = Afrikaans speaking pupils E = English speaking pupils A+E = Afrikaans + English speaking pupils

NT = Non-technical pupils (prospective) T = Technical pupils (prospective)

Ag = Agree with statement Dis = Disagree with statement χ^2 = chi-square values

RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
1. I like mathematics	48	9	37	7	0,07	175	33	80	12	0,21	223	42	117	19	0,12
2. No matter how hard I try, I have trouble working with mathematics	18	39	16	28	0,09	53	155	27	65	0,49	71	194	43	93	1,03
3. I'd rather work a short easy problem than a long interesting one	28	29	22	22	0,01	85	123	36	56	0,08	113	152	58	78	1,13
4. It scares me to have to take mathematics	14	43	13	31	0,11	23	185	18	74	3,23	37	228	31	105	4,98
5. I like mathematics very much	42	15	31	13	0,02	134	74	66	26	1,54	176	89	97	39	1,00
6. Next year I hope to attend a commercial high school															
7. Mathematics is very useful to everyone	54	3	41	3	-	195	13	88	4	-	249	16	129	7	1,04
8. Sometimes I work extra mathematics problems	33	24	14	30	0,21	95	113	42	50	0,001	128	137	56	80	1,84
9. I usually understand what we are talking about in the mathematics class	45	12	38	6	0,49	178	30	83	9	0,84	223	42	121	15	1,34
10. Mathematics is easy for me	32	25	24	20	0,03	120	88	47	45	1,13	152	113	71	65	0,97
11. It's fun to work with mathematics	48	9	41	3	-	170	38	79	13	0,51	218	47	120	16	1,99
12. My marks in mathematics are higher than that of most of the pupils in my class	22	35	20	24	0,48	86	122	37	55	0,34	108	157	57	79	0,05
13. I would like a job that doesn't use any mathematics	16	41	14	30	0,04	52	156	24	68	0,04	68	197	38	98	0,24
14. It makes me nervous to even think about doing mathematics	33	24	8	36	14,6	27	181	15	77	0,34	60	205	23	113	1,80

ANNEXURE 7.

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

A = Afrikaans speaking pupils E = English speaking pupils A+E = Afrikaans + English speaking pupils
NT = Non-technical pupils (prospective) T = Technical pupils (prospective)
Ag = Agree with statement Dis = Disagree with statement χ^2 = chi-square values

RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
15. I like to solve new problems in mathematics	45	12	33	11	0,05	167	41	80	12	1,52	212	53	113	23	0,56
16. I don't like to study mathematics	23	34	18	26	0,02	79	129	28	64	1,58	102	163	46	90	2,95
17. I have trouble with some of the terms and symbols used in mathematics	39	18	31	13	4,64	119	89	53	39	0,004	158	107	84	52	0,17
18. No matter how hard I try, I cannot understand mathematics	6	51	6	38	0,03	14	194	8	84	0,13	20	245	14	122	0,56
19. Mathematics is important in everyday life	55	2	41	3	-	201	7	90	2	0,04	256	9	131	5	0,02
20. I am more interested in mathematics than in most other school subjects	31	26	21	23	0,44	67	141	47	45	9,65	98	167	68	68	6,28
21. I am not willing to study mathematics any more than I have to	19	38	19	25	0,65	91	117	31	61	2,67	110	155	50	86	0,84
22. I feel relaxed and happy when working with numbers	36	21	34	10	1,71	121	87	60	32	1,32	157	108	94	42	3,74
23. Next year I hope to attend an Agricultural high school															
24. There is very little need for mathematics in most jobs	6	51	8	36	0,66	18	190	15	77	3,07	24	241	23	113	5,36
25. My marks in mathematics have usually been lower than my marks in other school subjects	11	46	20	24	6,80	78	130	33	59	0,07	89	176	53	83	1,14
26. I think that mathematics is a very dull subject	10	47	6	38	0,07	28	180	16	76	0,50	38	227	22	114	0,24

ANNEXURE 7.

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

A = Afrikaans speaking pupils E = English speaking pupils A+E = Afrikaans + English speaking pupils

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RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
27. I have always enjoyed mathematics	46	11	34	10	0,03	132	76	61	31	0,22	178	87	95	41	0,30
28. Mathematics is not very important for most people	18	39	14	30	0,04	54	154	29	63	0,99	72	193	43	93	0,87
29. I have a good feeling about mathematics	48	9	33	11	0,81	150	58	69	23	0,27	198	67	102	34	0,004
30. Mathematics make me feel worried and confused	15	42	12	32	0,01	44	164	26	66	1,80	59	206	38	98	1,58
31. Next year I hope to attend an Art school															
32. You need mathematics in order to get a good job	54	3	41	3	-	188	20	84	8	.001	242	23	125	11	0.001
33. I don't like mathematics very much	10	47	12	32	0,87	55	153	19	73	0.86	65	200	31	105	0.15
34. Mathematics is very interesting to me	46	11	32	12	0,50	145	63	72	20	2.33	191	74	104	32	0.89
35. I have a bad feeling about mathematics	18	39	14	30	0,04	37	171	16	76	0,007	55	210	30	106	0,09
36. Mathematics is important for the country	53	4	41	3	-	188	20	79	13	0.91	241	25	120	16	0,32
37. I often think "I can't do it" when a mathematics problem seems hard	33	24	28	16	0,14	119	89	49	43	0.40	152	113	77	59	0,02
38. Most of what we learn in mathematics class is not useful	7	50	5	39	0,03	14	194	11	81	1,65	21	244	16	120	1.16
39. I feel calm and confident when doing mathematics	43	14	26	18	2,35	146	62	67	25	0.21	189	76	93	43	0.37
40. I have never enjoyed studying mathematics	10	47	6	38	0,07	55	153	26	66	0,11	65	200	32	104	0,05

ANNEXURE 7.

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

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RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
41. My marks in mathematics are lower than that of most of the pupils in my class	19	38	14	30	0,003	74	134	25	67	2,04	93	172	39	97	1,68
42. Word problems in mathematics have always been difficult to me	19	38	25	19	4,66	87	121	33	59	0,94	106	159	58	78	0,26
43. Mathematics make me feel nervous and uncomfortable	12	45	14	30	1,00	40	168	17	75	0,001	52	213	31	105	0,55
44. My mathematics marks have usually been higher than my marks in other subjects	34	23	21	23	1,42	93	115	53	39	2,45	127	138	74	62	1,51
45. Mathematics helps in science and other subjects	47	10	37	7	0,003	187	21	82	10	7,52	234	31	119	17	1,18
46. I am good at working mathematics	29	28	25	19	0,15	125	83	58	34	0,23	154	111	83	53	0,32
47. Mathematics is less important than other subjects	2	55	8	36	-	11	197	10	82	2,25	13	252	18	118	7,61
48. I feel at ease in mathematics classes	41	16	31	13	,004	152	56	63	29	0,66	193	72	94	42	0,61
49. I find mathematics to be very boring	10	47	10	34	0,16	33	175	17	75	0,15	43	222	27	109	0,82
50. I would like to belong to a mathematics club	31	26	28	16	0,54	53	155	42	50	11,99	84	181	70	66	14,85
51. I am able to work mathematics without trying very hard	22	35	17	27	0,04	74	134	43	49	3,34	96	159	60	76	2,35
52. Mathematics is not very important in everyday life	5	52	3	41	-	25	183	21	71	5,74	30	235	24	112	3,09

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

A = Afrikaans speaking pupils E = English speaking pupils A+E = Afrikaans + English speaking pupils

NT = Non-technical pupils (prospective) T = Technical pupils (prospective)

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RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
53. I just don't like mathematics	13	44	11	33	,001	40	168	17	75	,001	53	212	28	108	0,02
54. I am not frightened or afraid of mathematics	43	14	30	14	0,34	170	38	69	23	1,78	213	52	99	37	2,99
55. I feel I could do better in mathematics if I tried harder	53	4	40	4	-	184	24	78	14	0,48	237	28	118	18	0,40
56. Next year I hope to attend a Technical High school	0	57	44	0	-	0	208	92	0	-	-	265	136	-	-
57. I feel tense and tight when someone talks about mathematics	19	38	16	28	0,01	42	166	13	79	1,19	61	204	29	107	0,15
58. Mathematics is one of my favourite subjects	36	21	30	14	0,10	123	85	62	30	1,84	159	106	92	44	2,24
59. Mathematics is a very worthwhile and necessary subject.	50	7	35	9	0,71	194	14	84	8	0,13	244	21	119	17	1,69
60. I remember most of the things I learn in mathematics	41	16	31	13	,004	166	42	72	20	0,09	207	58	103	33	0,29
61. I feel sure of myself when working mathematics	43	14	30	14	0,34	143	65	67	25	0,50	186	79	97	39	0,06
62. I like school very much	39	18	21	23	3,59	121	87	47	45	1,30	160	105	68	68	3,95
63. I don't like to study school subjects	10	47	16	28	3,67	65	143	35	57	1,32	75	190	51	85	3,53
64. I have never enjoyed studying	17	40	19	25	1,39	90	118	41	51	0,04	107	158	60	76	0,52
65. I have always enjoyed going to school	38	19	18	26	5,67	99	109	48	44	0,53	137	128	66	70	0,36

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

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RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
66. There is very little need for going to school for most jobs	8	49	6	38	0,05	16	192	6	86	0,01	24	241	12	124	0,01
67. Schoolwork makes me feel worried and confused	7	50	16	28	6,88	35	173	26	66	5,15	42	223	42	94	12,27
68. I feel relaxed and happy when doing school-work	40	17	31	13	0,04	141	67	57	35	0,97	181	84	88	48	0,53
69. School is very interesting to me	45	12	35	9	0,03	158	50	66	26	0,60	203	62	101	35	0,27
70. I think that school is very dull	14	43	12	32	0,006	27	181	29	63	14.4	41	224	41	95	11,90
71. Next year I hope to attend an Academic high school															
72. You need to go to school in order to get a a good job	55	2	44	0	-	202	6	87	5	0.56	257	8	131	5	0.001
73. My school marks have been unusually high	14	43	5	39	2,03	81	127	30	62	1.10	95	170	35	101	4.20
74. I do better than most of the pupils in my school	19	38	11	33	0,47	103	105	33	59	4.80	122	143	44	92	6.94
75. I don't have very high marks in school	28	29	25	19	0,32	87	121	47	45	2.21	115	150	72	64	3.29
76. Most of the pupils in my class know more than I do	18	39	20	24	1,49	67	141	38	54	2.32	85	180	58	78	4.38
77. My marks in mathematics are about the same as that of the pupils in my class	36	21	27	17	0,001	112	96	47	45	0,19	148	117	74	62	0.08

ANNEXURE 7.

QUESTIONNAIRE, RAW SCORES AND CHI-SQUARE VALUES OF STATEMENTS

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RESPONSES OF PUPILS

STATEMENT	Afrikaans					English					Afrikaans + English				
	NT 57 +		T 44 = 101			NT 208 +		T 92 = 300			NT 265 +		T 136 = 401		
	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2	Ag	Dis	Ag	Dis	χ^2
78. Most of my friends like mathematics	34	23	30	14	0,45	111	97	58	34	2,43	145	120	88	48	3,68
79. Most of my friends don't do well in mathematics	19	38	16	28	0,01	71	137	48	44	8,67	90	175	64	72	6,52
80. My friends think mathematics is important	43	14	33	11	0,03	169	39	67	25	2,70	212	53	100	36	2,18
81. Mathematics is not a fovourable subject of most of my friends	28	29	18	26	0,38	121	87	49	43	0,63	149	116	67	69	1,75

ANNEXURE 8.

COMPUTER PROGRAMME.

```
1.     Input  " STATISTICS"  ;  N $
2.     CLS : Print  "ATTITUDES"; N S;  "This is a "
3.     Print "Chi-square test programme"
4.     Print :  Print "press any key to begin"
5.     Pause  0 : CLS
10.    CLS  :  Print at 2,7 ;  "Chi-square test"
20.    Border 0 :  Print at 3,7;
25.    For N  =  1 to 3
30.    Plot 100,  14 0-N  * 16 : Draw 8 * 4, 0
40.    Next N
50.    For N  =  0 to 2
60.    Plot  100 + N * 16, 124
64.    Print at 9,  15;  "D"
65.    Draw  0,  -32
70.    Next  N
71.    Print At 7,  13;  "A"
72.    Print At 9,  13;  "B"
73.    Print At 7,  15;  "C"
100.   Input  "Enter value A : ";A
110.   Input  "Enter value B : ";B
120.   Input  "Enter value C : ";C
130.   Input  "Enter value D : ";D
140.   Let N = A + B + C + D
1000.  Let AD = A * D
1010.  Let BC = B * C
1011.  Let H (A+B) * (C+D) * (A+D) * (B+D)
1012.  If A < 20 or B < 20 then let ER = 1: Go to 2000
1013.  Let H = (A+B) * (C+D) * (A+C) * (B+D)
1014.  If  C < 2 0  or  D < 20  then let  ER = 1 : Go to 2000
1020.  Let G  =  N *  (AD-BC)  *  (AD-BC)
1040.  Let ans  = G
                  -
                  H
1050.  Print ans
1060.  Go to 3000
2000.  Rem Yates correction
2010.  Let  G = N  *  ((( ABS  (AD-BC))  - (N/2) )  *  (( ABS  (AD-BC)) - (N/2) ))
2020.  Print  G
              -
              H
2021.  Print
2030.  Print   "Note : Yate's"
2040.  Print   "correction"
2050.  Print   "Has been done"
2051.  Print
2070.  If A < 5  or  B<5  or  C<5  or  D <5  then print "This formula
       does not apply"
```

ANNEXURE 9.

TABLE OF TOTAL RESPONSES FOR CONSTRUCTS.

Desireable traits are shown with a(+)   Undesireable traits are shown with a(-)

CONSTRUCT	No of items	AFRIKAANS							ENGLISH						
		NON-TECH.			TECH.				NON-TECH.			TECH.			
		+	-	TOT	+	-	TOT	χ^2	+	-	TOT	+	-	TOT	χ^2
Anxiety about mathematics	9	355	158	513	278	118	396	0,11	1453	419	1872	630	198	828	0,73
Self-confidence about mathematics	9	338	175	513	251	145	396	0,61	1251	621	1872	565	263	828	0,52
Perceived usefulness of mathematics	11	560	67	627	418	66	484	2,26	2071	217	2288	881	131	1012	8,91
Self-reported achievement in mathematics	5	176	109	285	122	98	220	2,04	555	485	1040	263	197	460	1,87
Peer influence on attitude towards mathematics	4	144	84	228	117	59	176	0,48	504	328	832	212	156	368	0,93
Self-perceived ability in mathematics	4	142	86	228	101	75	176	0,99	554	278	832	253	115	368	0,54
Self-reported general academic achievement	4	101	127	228	59	117	176	4,82	446	386	832	162	206	368	9,38
Liking for school	10	446	124	570	300	140	440	13,03	1528	552	2080	628	292	920	8,53
Interest in and liking for mathematics	20	822	318	1140	609	271	880	2,02	2769	1391	4160	1310	530	1840	12,58

ANNEXURE 9.

TABLE OF TOTAL RESPONSES FOR CONSTRUCTS.

Desirable traits are shown with a (+)

Undesirable traits are shown with a (-)

CONSTRUCT	AFRIKAANS + ENGLISH						
	NON-TECH.			TECH.			
	+	-	TOT	+	-	TOT	χ^2
Anxiety about mathematics	1808	577	2385	908	316	1224	1,15
Self-confidence about mathematics	1589	796	2385	816	408	1224	0,001
Perceived usefulness of mathematics	2631	284	2915	1299	197	1496	11,94
Self-reported achievement in mathematics	731	594	1325	385	295	680	0,34
Peer influence on attitude towards mathematics	648	412	1060	329	215	544	0,06
Self-perceived ability in mathematics	696	364	1060	354	190	544	0,05
Self-reported general academic achievement	547	513	1060	221	323	544	17,36
Liking for school	1974	676	2650	928	432	1360	17,59
Interest in and liking for mathematics	3591	1709	5300	1919	801	2720	6,54

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