CRITICAL EVALUATION OF THE TEACHING AND LEARNING OF TECHNICAL DRAWING IN BLACK SCHOOLS

BY

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DECLARATION

I declare that:

The topic and contents of this study is my own work, all the sources used or quoted have been indicated and acknowledged by means of a complete reference and that this dissertation was not previously submitted by me for a degree at another university.

SUMMARY

This study evaluated the teaching of Technical Drawing in Black schools in the Vaal Triangle under the jurisdiction of the Department of Education and Training. The purpose of this study was to describe the form of tuition presently applied in the teaching and learning of Technical Drawing. This study further attempted to identify difficulties that Black pupils, who are being taught through the medium of a second language, are experiencing in forming concepts in Technical Drawing as a key subject in technical education.

The account used the techniques of illuminative evaluation. This included an observation checklist and structured interview questionnaires.

The historical background of the provision of technical education in developed and under-developed countries was discussed in the light of developing skilled manpower which is required for economic growth. The shortage of skilled manpower to meet the demands of the industries and business world in the Republic of South Africa was also discussed.

An attempt of the government to meet the demands of industries through technical education among Blacks was highlighted. Problems associated with this attempt manifest themselves in the teaching of Technical Drawing.

This study showed that poor concept-forming in the learning of Technical Drawing among Black pupils is the fundamental problem.

Recommendations concerning methods of tuition, in order to promote clear concepts among Black pupils in the learning of Technical Drawing, are made.

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CHAPTER 1

INTRODUCTION AND BACKGROUND TO THE PROBLEM

1.1 INTRODUCTION

According to Horrel (1968:6) an important objective pursued in the educational field as a whole, is to bring about a self-supporting Black community which can develop fully in every sphere: social, cultural, economic and political. Thompson (1981:4), in support of the above idea about education, says that all countries possess a firm belief in the power of education as a means to assist in national development. National development, among other things, includes fundamental change in the lives of people. This change will be extended into the political, social as well as economic spheres. Through education countries are furthermore seeking to preserve as much as possible the distinctive local cultures which, in spite of the problems they may present, may also enrich their national life and contribute towards the evolution of a national cultural identity.

Thompson further points out that all countries are undergoing far-reaching processes of social change. This change is sometimes the consequence of conscious planning, but it can also, to a very considerable extent, be independent of planning. These processes, through their incoherence and the variable nature and speed of their impact upon various sections of the national population, are tending to create new conditions of tension and strain (Thompson 1981:5).

The practical examples of these changes and processes Thompson is referring to, are the technocratic eras, which demand technical skills and knowledge. In our experience of everyday life, it is being observed that the demand of the technocratic era is not only the creation of jobs, but also careers in the modern industrial and business world. It is further observed that the educational response to the needs of development is dominated by demands of the modern sector for high-level manpower and consequently by the formal school system.

In order to meet these demands of the technocratic era, technical education has been introduced in Black schools in South Africa by the Department of Education and Training. This step has resulted in one of the biggest and most logical projects in the history of Black education. A large number of secondary schools in South Africa have already been erected to cater for this type of education. In other regions, such as Natal, the Highveld, Johannesburg, Mamelodi, Orange Vaal, etc., secondary schools which cater for academic education, have accommodated technical subjects such as Technical Drawing. It is worth mentioning that such trends offer greater opportunities for societal and individual self-advancement, with status as well as financial rewards for those who can apply their energy and ability more successfully.

The idea of accommodating technical subjects in academic high schools, gives rise to a key problem. According to the Human Science Research Council (HSRC 1981:74), it is generally preferable to establish comprehensive schools by changing a career high school into a comprehensive school, rather than an academic high school into a comprehensive high school. The HSRC report further states that if an academic high school is changed into a comprehensive high school, the importance of technical education tends to be dominated by that of academic education unless careful preventative measures are taken.

To provide children with a sufficiently wide choice in career opportunities, the Human Science Research Council further recommends that comprehensive high schools should preferably be large. This means that comprehensive high schools should not offer a limited choice of trades for pupils to follow.

The curriculum at comprehensive schools offers the following technical subjects which entail both theory and practice (DET 1985:1).

SUBJECT	ABBREVIATION
Electrical work	EW
Electronica	EL
Woodworking	WW
Fitting and Turning	FT
Welding and Metalwork	WM
Technical Drawing	TD

Such subjects have never been taught in Black urban schools since the implementation of Bantu education in 1954.

The nature and the demands of these subjects are different from those of the academic school subjects taught in schools under the jurisdiction of the Black Education Department. It is therefore probable that a number of problems can be experienced in the teaching and learning of Technical Drawing in Black schools.

1.1.1 Stating the problem

Empirical evidence shows that the Republic of South Africa, as a developing country, has characteristics of both developing and less developed communities. These characteristics have certain implications for teaching and learning in the different communities.

According to Swart (1988:178), meaningful learning occurs only if new information is linked to existing relevant concepts. This statement contains the key to what learning actually is, namely concept formation. He further points out that one of the main problems facing teachers in less developed communities today, is the introduction of new or unknown concepts to the learners. The difficulty experienced lies not so much in introducing the concepts, but in establishing them. This implies that in less developed communities, foreign or new concepts can be understood if they are linked up with the pupils' conceptual framework.

Should the above contain the solution to how meaningful learning can be achieved, the researcher would suggest that this concept also be used as a solution to the problems experienced in the teaching of Technical Drawing in Black schools.

Lindeque (1986:67) also refers to the above when he says that in Black education, pupils are exposed to different experiences which seem to affect their cognitive development. The differences in educational experiences, due to the lack of qualified teachers, the high pupil-teacher ratio, the lack of teaching media and the lack of continuity between the cultural world of the family and that of the school, have an influence on the cognitive state of the pupils. The problems experienced with a foreign medium of instruction after standard two have a formative influence on the cognitive state of the pupils. The socio-cultural experiences of Black pupils also have an influence on their cognitive state as the emphasis on traditions at home is in conflict with the Western-orientated syllabi at school.

Gagné (1985:17, 136), in support of Lindeque on the value of a cognitive basis, says that a firm cognitive basis is necessary for the child to form new concepts.

1.1.1.1 Black language problem

To what extent is the language of the Black man capable of expressing the concepts in Technical Drawing clearly and economically?

1.1.1.2 Didactical problem

Are the teaching methods, applied in the teaching of Technical Drawing appropriate to the learners who are instructed through the medium of the second language? Are these teaching methods used in such a way that rote-learning is encouraged at the expense of learning by insight?

1.1.2 The purpose of the research

The purpose of this research is to study and describe the form of tuition presently applied in the teaching of Technical Drawing in Black schools under the jurisdiction of the Department of Education and Training.

It further aims at identifying difficulties that Black pupils may be experiencing in forming concepts in Technical Drawing. After discussing the teaching methods being applied and identifying difficulties that Black pupils experience in forming concepts in Technical Drawing, the researcher will make recommendations regarding the most suitable methods of tuition which will promote the forming of clear concepts in the subject by Black pupils.

1.1.3 Hypothesis

Black pupils, who receive instruction through the medium of the second language, do not perform well in learning new concepts in Technical Drawing, because their conceptual framework is not utilized in such a way that learning by insight is promoted at the expense of rote-learning.

1.1.4 Literature review

It will be of importance in this study to establish the problems in the teaching and learning of Technical Drawing in Black schools. From literature reviews, it appears that Black pupils experience problems in the learning of subjects which require a high level of abstraction or concept forming such as Physical Science and Mathematics. The content of Technical Drawing, par excellence, requires this ability. As a result, all the problems associated with the teaching and learning of Physical Science and Mathematics are applicable to Technical Drawing.

According to Van den Berg (1978:23) the poor insight of Black pupils into Mathematics is the result of an inability to think abstractly due to the influence of the materially improverished environment in which they are brought up and limitations in the vocabulary of their mother-tongue. By limitations in the vocabulary of Black pupils' mother-tongue, Van den Berg means that a Black language lacks certain technicalities in expressing certain concepts in Science clearly and economically. This problem is aggravated by the pupils' poor control of the official language which is used as a medium of instruction.

Besides language and a materially impoverished environment, (Dreyer (1977:81) reveals that a nation's way of living, which is determined by its culture, has a significant effect on the intellectual development of the child. Irvine (1969:231) supports Dreyer's view when saying that the skills which pupils learn efficiently are those which are determined by their society's system of values. In other words, the society's system of values has a major influence on the formation of concepts, because it not only determined the style of upbringing, but also the whole structure of conceptual thinking.

Groenewald (1976:30) in support of the role of culture in the formation of concepts, says that there is a possibility that people from different cultural groups have the same experiences, but that each specific group assigns different meanings to these experiences. Consequently, the cultural group to which a child belongs and the milieu in which he grows up, have a determining effect on the contents and quality of his concepts. Groenewald's statement implies that different patterns of ability exist among different cultural groups. Groenewald further points out that one of the major problems in the learning of skills in technical education, is the inadequate actualisation of the individual child's intelligence.

The notion of culture, a societal system of values and social milieu as discussed, is summarized in the phrase, "conceptual framework" by Garbers (Swart 1988:178). This conceptual framework, in which the child is brought up, is built up throughout his life by spontaneous experiences and those planned by the education. A complicated combination of factors influence the child's formation of a conceptual framework, for example:

The values a child encounters.

Human beings and norms the child identifies with throughout life.

The emotional refinement and differentiation that develops.

New emotional dimensions added to the child's life, spontaneous maturation and growth; and the refinement and development of cognition.

According to Duminy (1967:39) the principle of perception is not someting new. For centuries the psychology of cognition has taught that knowledge is based on, or has its starting point in, concrete experiences and perception. In fact, the most complicated learning relies on sensory perception of the concrete world. This aspect is further emphasized by Swart (1988:178) when he views conceptualization as part of the didactic reality. As a result, he puts more emphasis on aiding learners in those aspects of conceptualization which could influence their cognitive state. This can be achieved by using all encompassing didactic aids, such as the video. This improves conceptualization by providing basic concepts and explaining unknown concepts.

Swart (1988:178) does not reject any aspects raised by other authors, which are said to be hampering learning and the formation of clear concepts, like a materially impoverished environment and a cultural system of values. Nevertheless, he feels that this view is rather narrow. He summarizes the crux of learning problems by saying that the problem in learning is caused by the poor development of concepts. Poor concepts, according to Swart, have a much wider perspective which not only stem from poor background circumstances, but also from poor learning, inadequate teaching techniques and the use of the second language as a medium of instruction.

The aspect of poor concepts, seen as a much wider perspective by Swart, allows the researcher to incorporate motivation and language problems into this literature review.

1.1.4.1 Literature review on motivation

Duminy (1967:34) shows the importance of motivation in learning, when saying that arousing and maintaining the will to learn, is a basic concern of the school and an essential part of the teacher's work. He further says that a motivated learner, learns more readily than one who is not motivated.

Behr (1977:59), in support of Duminy, says that motivation lies at the root of the pupils' wanting to learn, and persisting in their efforts. A pupil who is highly motivated, experiences a deep need to achieve. Motives are energizers, selectors, directors of activity and are closely related to attitudes and interests. All learning is, in a sense, dependent on motivation.

Engelbrecht et al. (1987:50) mentions that there are numerous opportunities, means and techniques to create and stimulate motivation and conditions for effective learning in the situation of instructive education. The important thing to remember here is that real motivation comes from an activity, a question, an example, a task or an object that really starts pupils thinking about the relevant matter.

Lindeque (1986:58) in support of the idea that real motivation comes from activity, mentions that the learner will be motivated to learn by any activity if he experiences the activity to be relevant to his life-world. If his conceptual framework does not provide for this, the learner's situatedness should be taken into account and this should serve as the point of departure for anchoring new concepts. It is also important to note that the relation between the new item to be learnt and relevant items in the conceptual framework must be non-arbitrary and substantive.

As the main problem for the learner in the formation of concepts is sorting out the critical attributes of a class of stimuli to which he is exposed, it is the teacher's duty to assist the learner in this process. The teacher should also help the pupil to understand the meaning of the concept and to provide concrete experiences related to the object in order that the learner may discover its critical attributes. Teaching should also provide for the correct learning of definition and for the concept to be encountered in appropriate context according to the learner's conceptual framework (Lindeque 1986:58).

The above-mentioned fact implies that teachers who cannot motivate pupils to learn and who lack experience in, or knowledge of, concept teaching techniques shouldn't use the materially impoverished or cultural environment in which their pupils are brought up as a scapegoat to disguise their own inadequacy.

1.1.4.2 Literature review on language

Engelbrecht (1984:93) says that the mastering of a language plays an important role in the child's ability to break through his affective connection with things he perceives. He further says that cognitive development and the acquisition of language go hand in hand. It is impossible to think of learning without considering the role that language and language acquisition have to play in order to make learning meaningful. It is impossible to describe any type of meaningful learning if constant reference is not made to language as a means whereby learning takes place.

Swart (1988:178) says that the development of cognition is dependent on the development of language. Language not only follows, but also anticipates and guides cognitive activity. The human being creates and lives in a symbolic world, a world of meanings, and especially through language the child has to discover meanings. In the child's conception of natural phenomena and Science, it is important to note that the meanings as discovered by the child and chained to his language will play an important role in his further discoveries of meaning. The child should experience 'geborgenheid' (security) in order to explore his world, as well as a sense of accompaniment. The meaningful experiences of the small child is of utmost importance to the further development of the child.

Schmidt (1973:62) mentions that access to language presupposes active participation and involvement in a world of shared human menaings and in the culture of the group to which the child belongs, and is therefore central to the child's socialization and enculturation. He further mentions that cognition is varied and that language and the nature of cognition as well as thinking cohere. The personal non-cognitive conceptual framework changes due to the child's cognitive development. Cognitive development depends on what the particular culture really contains and makes available.

A survey of the problems which teachers encounter when using English as a medium for teaching science to pupils whose mother-tongue is an African language, was conducted in Northern Malawi. The results of this survey, showed that pupils first think in the mother-tongue and then directly translate the sentence into English. As a result, pupils experience problems in differentiating between certain words like 'gas', 'air' and 'wind'. Besides the problem of the vocabulary of African languages, there is also the aspect of grammatical errors. which obscure the meaning of certain words (Case 1968:43).

Ausubel (1969:53) supports the findings of the above-mentioned survey, when indicating that problems are experienced with the learning of concept-names due to the foreign medium of instruction and the fact that concepts are not encountered in the appropriate context.

This implies that, since Black pupils are learning Technical Drawing through the medium of a second language, there is a strong probability that they are experiencing problems in understanding concepts.

1.1.4.3 Practical context of the problem

All the reviewed sources discuss the problems which hamper clear development of concepts in Black pupils on a theoretical basis. In this section, the researcher attempts to discuss societal values, within a practical context and indicates the conflicting system of values of the school and that of Black pupils.

As experienced in everyday interaction in the Black community, a societal system of values among other things, includes the following: listening, learning the different language registers appropriate to their parents and peers, and learning rules of observance and avoidance. These skills are learned together with an inherent system of concepts that exerts social control, which, in turn, compels the development of certain cognitive skills.

The researcher practically experienced, as a Technical Drawing teacher, that the school system, through subjects like Technical Drawing, introduces skills whose function is quite different from the above-mentioned. Among others, the following can be mentioned: clear development of concepts, a highly developed ability to imagine and to perform, and sufficient understanding of and communication in the second language. In paragraph 1.4 Van den Berg (1978:24) mentions the limitations of the Black pupils' mother-tongue in explaining certain concepts clearly. It can therefore be concluded that these skills which the school develops, cannot be conveyed accurately and economically in the Black pupils' mother-tongue, because they are not central to the system of values of Black pupils. As a result, there is a probability that Black pupils will experience problems in learning them.

1.1.5 Definition of concepts

Meanings attached to a word can be many and varied. Linguists like Wittgenstein in Bernstein (1979:67) view language as a tool, because the same words in a language can have different meanings in different contexts. The meaning of a word might differ depending on the meaning attached to it by a specific community. For this reason, it is necessary to define the context in which a particular word or concept that might have different meanings is used. This will help to eliminate misunderstandings and thus facilitate a proper understanding of a given word in the manner in which the researcher wants it to be understood.

1.1.5.1 Critical evaluation

A critical evaluation can be defined as an objective or scientific judgement which means that the person evaluates facts by judging them in accordance with norms that usually lie outside his own taste or preferences. The objective of such an activity is to give a reasoned or factual account of what exists.

It is strictly aimed at assessing probabilities in the light of established facts. Critical evaluation entails reference to a norm, or standard of merit. Appreciative judgements, referring to those which are based entirely upon tastes, dislikes, likes and preferences, are totally excluded or ignored.

In this study, the teaching and learning of Technical Drawing are evaluated in the light of the nature and demands of the subject as a norm, rather than in the light of the preferences or likes of the researcher.

However, if the researcher's preferences surface anywhere in this study, it should be kept in mind that logically, findings are judgements, facts to which truth values may be assigned.

1.1.5.2 Teaching

According to Van Rensburg et al. (1979:373) teaching is educative. Teaching concentrates on intellectual actualisation, including in its scope bodies of knowledge (such as knowledge of values and norms) and skills useful for communal existence. Teaching also takes place outside the school environment and similarly school exists not merely for teaching, but also for education provided by means of instruction. The term educative teaching serves very well to describe this higher function of teaching. It is, as such, concerned with considerably more than the child's intellectual activities, it penetrates to his inner, spiritual existence. Duminy and Söhnge (1986:3) explain teaching within the context of this study, when saying that it means that the reality must be unlocked to the child through factural instruction.

According to Fenstermacher (1986:37-38) teaching is the involvement of two or more persons in an activity. In this activity, one person who knows, understands or has the skill to do something in trying to convey it to the other person, the learner. This implies that teaching takes place between people, in a situation where one is the possessor or provider of knowledge or skill and the other one the recipient of knowledge or a skill. Fenstermacher further points out the key aspects of the teaching activity, namely contents and intents or aims. He then concludes this definition by saying that teaching is an interaction between two or more people, one of whom possesses some knowledge or skill or other form of content and the other who does not, and the possessor intends to convey the contents to the one who lacks it. Lastly Fenstermacher indicates that in this teaching activity two people must be engaged in a relationship for this purpose.

1.1.5.3 Learning

Learning occurs when the change that takes place in a child with regard to his relationship to reality is meaningful. It is a meaningful human activity and a spontaneous mode of being. It is an opportunity to achieve greater independence and adulthood in the life of the child (Van der Stoep 1984:48).

Hughes (1959:32-33), in elaboration of the fact that learning is a human activity, says that when he speaks of children learning, people usually think of teachers teaching, thus overlooking the fact that in pre-school years children learn very rapidly without any organized teaching and without any sub-division of knowledge into subjects. Children are joyfully and playfully active, and as a result they develop bodily skills, they gain knowledge, and they learn how to adapt their behaviour to the needs of their society. All three types of learning, that of bodily skill, knowledge and appropriate social behaviour - take place simultaneously. Under the influence of the creative impulse children approach environment as a vague unanalysed whole, and they begin to explore it in all directions.

In the course of this exploration they are continually embarking on some new project, for example, being a railwayman, giving a tea-party or gardening. The same principle is at work : children plunge into a complex experience and they take the learning of details in their stride.

Hughes further says that observation of young children nevertheless shows that though most of their learning is done almost unconsciously, they occasionally find it necessary to mark time. In carrying out a project they at times discover the need for some skill or knowledge that they lack. They then set to work with redoubled effort. If it is a skill they want to acquire, they surprise grown-up people by the determination with which they practise, if it is knowledge they ask questions. The fact is that, in carrying out their self-chosen projects children are so interested and absorbed in what they are doing that they will, if necessary, cheerfully perform repetitive work that would otherwise be extremely boring. This intense interest is doubtlessly the secret of the rapid progress that children make during their first three years. He concludes by saying that instinctive tendencies are the prime sources of the intense interest that facilitates the processes through which children learn in early years.

Kolb and Fry (1975:34) define learning not only as an activity in which an individual gains contact with his own experience, but also as the cognitive process which enables him to make sense of this experience.

According to them, effective learning requires four different kinds of abilities:

<u>Concrete experience abilities</u>

The learner must be able to involve himself in new experiences freely without being tied to pre-conceived notions.

<u>Reflective observation abilities</u>

He must be able to observe these experiences and reflect on and consider them from many perspectives.

<u>Abstract conceptualization abilities</u>

He must be able to transform his observations and reflections into theories and hypotheses by integrating them with previously acquired knowledge and speculating about possible outcomes.

<u>Active experimentation abilities</u>

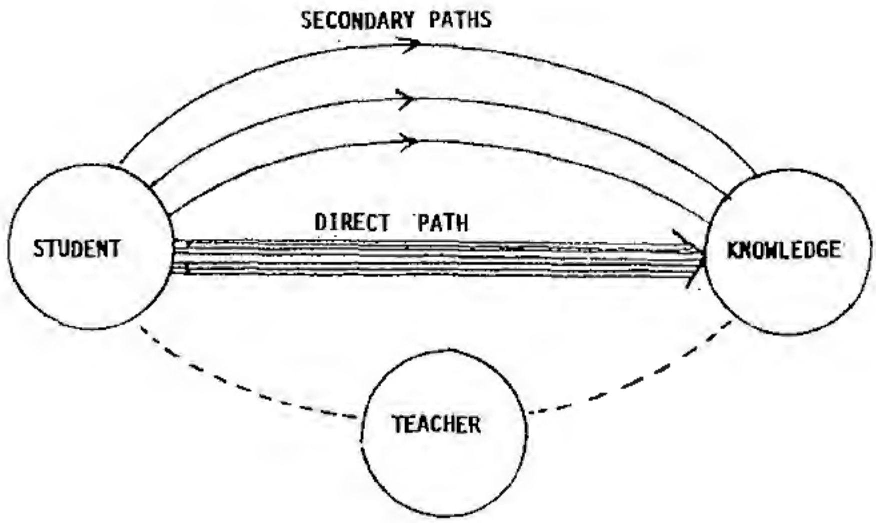
He must be able to translate these theories into active experimentation. These abilities tend to be organized in two dimensions:

Concrete experience ⟷ Abstract conceptualization

Reflective observation ⟷ Active experimentation

The learning process involves a continual shift from actor to observer and specific involvement to general analytical detachment. Kolb and Fry are here describing the same essential features of an individual's developmental or learning cognitive process which enables environmental adaptation to take place.

Thomas et al. (1963:6) defines learning as an influenced activity which follows certain paths. The figure below illustrates the definition.



This illustrates the position of the teacher who does not obstruct the process of learning, but is sufficiently in contact with the situation to be able to influence it. In the absence of the teacher, learning would still be achieved, provided that the student was sufficiently motivated, but there would be no guarantee that he would follow the efficient and optimum direct path. He might well follow one of the secondary paths to learning which, as the figure indicates, would be less direct and probably more difficult to traverse.

An overall definition of what learning is, is contained in the article of Swart (1988:179) wherein different theorists refer to learning as the formation of concepts. Combining all the provided definitions in paragraph 1.1.5.3, it can be said that the child can only attribute meaning to an aspect which fits or registers within his conceptual framework.

From the above-mentioned definition, it is clear that learning is different from memorizing. The latter is the reproduction of information, facts or skills without having a clear concept, while learning is attribution of meaning and above all, formation of concepts.

1.1.5.4 Technical Drawing

The word "technical" is derived from the Greek "technikos" or "techne" meaning art, or pertaining to some particular art science or trade. It further means a particular field of knowledge pertaining to mechanical art.

The word "drawing" is defined as an art of portraying the way of life and customs of a specific time through pictures. As a result, the first drawings were associated with pictures, because of the absence of dimensions.

Technical Drawing therefore is a field of knowledge of scientific dimensional representations or illustrations pertaining to mechanical art.

1.1.5.5 Black

According to Population Registration Act 30 of 1951 Section 1, "Black" is a person who is, or is generally accepted as, a member of any aboriginal race or tribe of Africa.

Black, within the context of this research, refers exclusively to people who speak an indigenous African language as their first language or mother-tongue.

1.1.5.6 School

According to Van der Stoep (1984:155) the school is that structure which stands in a clear relationship to the cultural, economic, religious and social activities of a community. This leads to the acceptance in certain circles that the school has its origin in one or more of these differentiated occupational structures of society. The implication is that if a school is not orientated to, or concerned with, a certain occupational field, it will not have the status of a school. The school is further defined within the context of its aim, namely to orientate the child for occupational life in the community.

A school can further be defined as a place where education takes place. According to Van der Stoep (1984:72-75), education means forming. The nature of forming is closely associated with the structure of the teaching. As a result the teacher is the only person who can guarantee the formative nature of his teaching. Forming releases man from bondage and leads him to a given concrete reality, including the reality of norms and values. Forming is therefore a creation of a new inner attitude. This means that the formed person is placed in a new harmony with the surrounding reality.

Formation of concepts indicates an intervention in man's intellectual life. Forming makes a deep impression on one's conscious life. It modifies every aspect of a human being's life not only certain mental abilities. Forming is the way of exposing the human being to the reality towards which and in terms of which the person must eventually aim via contents. Forming involves the whole person and radically influences every facet of a human being with regard to his style of living which will manifest itself.

Within the context of this research, a school will refer to a formal educational institution where structured knowledge is passed on to pupils by professionally trained teachers.

1.1.6 Programme

Chapter two is devoted to the historical background of technical education in the light of the development of skilled manpower in developed and underdeveloped countries, including the Republic of South Africa.

Chapter three is devoted to the pilot study, final construction of the questionnaire and empirical investigation of problems in the teaching and learning of Technical Drawing in Black schools.

Chapter four is devoted to the research results of the data collected.

Chapter five is devoted to the scientific analysis and interpretation of the research results.

Chapter six is the conclusion and offers recommendations resulting from this study.

1.1.7 Summary

This chapter attempts to introduce the problem and provides background to it.

In the next chapter a historical background of technical education in developed and underdeveloped countries, including the Republic of South Africa, is discussed.

CHAPTER 2

HISTORICAL BACKGROUND OF TECHNICAL EDUCATION IN DEVELOPED AND UNDER-DEVELOPED COUNTRIES INCLUDING THE REPUBLIC OF SOUTH AFRICA

2.1 INTRODUCTION

The aim of this chapter is to provide a historical background of technical education. Knowledge of this will help in the understanding of developments in technical education in other countries and the Republic of South Africa. It will further provide a historical overview which will shed light on problems being experienced in the provision of technical education in Black schools. The historical background in this study will be based on the structure as a whole, the process and product of technical education.

Structure refers to the comprehensive planning of technical education. **Process** refers to the instructional programme, curriculum and teaching facilities, and **product** refers to graduates, drop-outs and number of pupils enrolled at technical high schools.

Generally, the establishment of technical education and its development is promoted by the urgency to meet the training needs of commerce and industry. The need for the establishment of technical education is defined as a training and preparatory education for a "design and make" type of education (HSRC 1981:138).

In industry there is an increasing awareness of the many ramifications of the technological change which is taking place. Jobs requiring less skill are being replaced by new, more sophisticated jobs, and workers can no longer plan on remaining in one job during the course of their working years. Even the professionals who may not change jobs, have to spend a considerable amount of time on trying to keep abreast of the latest development in their area.

The pressures of the times have not only been exerted on the workers, but also upon education to provide the timely knowledge and skills needed to keep pace with such developments. This confirms that there is a great need for the expansion of technical system in most, if not all, of the service areas.

The crux of the matter is that appropriate education should meet the demands of the country. In industrialized countries, education should be based on the new demands of industry and commerce. Education of such nature can improve training in skills for the development of industries, and also modern social services, increasing the readiness to learn new techniques required for innovation and change (D'Aeth 1975:109).

In African countries, education should be based on the demands of agriculture. Education of such nature can improve the quality of rural life, especially the level of agricultural skill with the aid of literacy, and the opportunities for richer cultural life (D'Aeth 1975:109).

Thompson (1981:105), in support of D'Aeth's views on education in rural areas, says that concern for rural areas and recognition of the importance of meeting the needs of predominantly rural people is, of course, nothing new. He points out that official policy for half a century and more has consistently stressed the need for agriculture to form the economic backbone of African countries and for encouraging the steady evolution of rural communities towards more satisfying ways of life. This would enable rural people to maintain their social and cultural integrity whilst mobilising their innate capacity to contribute to their own development.

D'Aeth (1975:39), recommends that rural education should pay special attention to how modern technological equipment can be used to improve the standard of agriculture. Teachers should indicate to pupils the importance of education and the need to acquire appropriate skills for the labour market. The purpose is to create harmony between the school and industry or natural resources so that the students should not later be found lacking in skills necessary to attain maximum productivity in industry or the utilisation of natural resources.

2.2 DEVELOPMENT OF SKILL THROUGH TECHNICAL EDUCATION

High technology improves the standard of living. In so-called under-developed countries people are often still maintaining the same standard of living as they were centuries ago. The farmers do not produce much, so there is a constant shortage of food. There are not enough clothes or houses, because these things are still produced by old methods. Most people in under-developed countries do not have things they need for a fairly comfortable life. They certainly do not have luxuries that people in industrialized countries usually enjoy. To attain a good standard of living, a country must know how to use its natural resources wisely, whether these are water, or coal for power, iron and other minerals, forests, soil for farming or land for grazing (Miller, 1969:44-50).

However, there are a few under-developed countries which have been doing something to improve their problem of under-development. Thompson (1981:108), points out that in the beginning of the 1920's certain African countries like Nigeria, Tanzania and Zaire were engaged in the creating of major hand-settlement schemes, utilizing advanced production technology. Such settlement schemes had some value where the rural population was not widely dispersed so that support could be readily afforded, and where the pressures of a growing population demanded the development of new and marginal land.

Consequently there was rapid growth in a number of such schemes in many parts of Africa, but equally quickly, their deficiencies were revealed. They were found to suffer from sociological problems associated with the formation of new communities and from dependence upon expert management, which was in short supply. Their main disadvantage, however, was that they proved inordinately expensive.

The failure of land-settlement schemes in certain African countries, implies that human resources must be developed and used wisely. People who are to run the economy must have education in technology and business management. Those who are to work in the industries must learn how to operate machines and keep them in good working order.

According to Thompson (1981:97, 298) schools and universities do not afford students much opportunity to practice the skills they are learning in the job situation in the communities. Wanat and Snell (1980:14) support the above view, when saying that although comprehensive high schools may contain some technical workshops, they often do not have adequate facilities to train all of their students who are interested in learning the skills of various occupations. The skills learned in comprehensive schools are frequently inadequate for employment purposes. It can therefore be said that training levels for skilled workers in the institutions of technical educational of most developing countries do not meet the growing needs of production. This also results in a number of graduates each year entering industry with very little practical knowledge about their chosen careers.

It is therefore necessary for a country which is aiming at development and advancement, to pay special attention to technical and university education, which will equip and develop manpower with the necessary skill required for the economic growth of the country.

2.3 TECHNICAL EDUCATION IN UNDER-DEVELOPED COUNTRIES

D'Aeth (1975:6) refers to under-developed countries as "Third World" countries. He explains the term, "Third World", as a genetic name for the very poor, mostly ex-colonial, countries of Africa, Asia and Latin America. This term has become widely used in the last fifteen years. The concept originated in the "cold war" between the USSR on the one hand and Europe and the USA on the other, during the years which followed the Second World War.

D'Aeth (1975:9) reveals that there are a number of factors which hamer development in the Third World countries. Among these are: shortage of skill and a whole complexity of associated requirements in modern marketing, transport, communications, banking and other services. Most people in under-developed countries suffer miserably on account of inadequate nutrition, housing, health and other physical conditions. This implies that people live in socially undeveloped conditions with a poor community life, especially those in urban and rural slums.

In such countries, economic growth remains of prime importance. However, D'Aeth further explains why the economic growth of under-developed countries cannot increase at a faster rate. The main or key problem is the gap between rich industrial nations and poor agricultural countries which has grown wider over the last two decades. This has happened because there has been little prospect of improvement in industry. The balance of trade may change in favour of primary producers as an outcome of the oil crisis. Nevertheless, most Third World countries wish to have some industrial development, both to ensure economic growth and employment and to secure their independence (D'Aeth 1975:41).

The problems mentioned above require a supporting base of technical education at appropriate levels. All nations also wish to educate their own administrators, professional people and specialists of all kinds. Nevertheless, few Third World countries can rely on industrial growth for their development. For most of them the future depends, of necessity, on rural development and this, in turn, depends on better living conditions and amenities, as well as improved agriculture to procure higher earnings. Moreover, development in the rural areas is the most important contributing factor to reduce the size of families. Population control has become a vital issue world-wide to prevent a further rise in unemployment. Education on appropriate lines will have to play an integral role in achieving the necessary transformation (D'Aeth 1975:41-42).

In the next paragraphs, reasons will be provided for the failure of the educational system of most under-developed countries to meet all the necessary requirements for development.

The cost of education, like that of other social services is the responsibility of the government, and elimination of fees is far more necessary in poor countries than in rich ones. The Third World countries have, by definition, a low Gross National Product (GNP) per head of the population. The cost of primary schooling in such countries is relatively high, because the salaries of teachers are high in relation to the Gross National Product per capita, which is very low. This is so, even though the standard of education is far below that of schools in advanced countries. The comparison here is based on the availability of facilities, attainments and scope of the curriculum (D'Aeth 1975:46).

In Mali, for example, the cost per pupil for a year of primary education is 16 000 Mali francs, and the average income a head is 40 000 Mali francs. This means that, primary education costs about 40 per cent of the average income. In Latin America and Asia the figure is about 10 per cent, still impossibly high for universal schooling when the income level is so low. In Western Europe comparable figures are about 6 per cent for France, 9 per cent for Britain and nearly 20 per cent for Scandinavia (D'Aeth 1975:46).

The pattern, in most Third World countries is that civil servants, including teachers, have disproportionately high salaries, as well as security tenure. This makes them a very privileged group occupying between one-third and two-thirds of the small wage-earning sector - between 1 per cent and 5 per cent of the working population. Naturally this privileged group is in a sufficiently strong position to oppose moves to significantly reduce the differentials. As a result it constitutes a serious barrier to economic growth and expansion of education. What is more serious in most Third World countries is that schools were developed along Western European lines to produce only civil servants, including teachers. The fact that schools teach wrong attitudes and skills, which are divorced from the indigenous cultures, is a serious obstacle in the way of successful education in Africa (D'Aeth 1975:46).

Generally, an education system of such a nature is not essential for development, because it has nothing to do with the improvement of rural living conditions. This means that in less developed countries with essentially agrarian economies it promotes the tendency to leave farming, thus contributes to unemployment in urban areas. It is therefore to their advantage to teach agriculture and to instil a love for farming at primary school level, because this will contribute to solving the problem of urban unemployment.

> "Educators in Africa were constantly under criticism. They were criticised for providing too superficial an education and for providing it to too few children, for being too much bound by external examinations, for being too bookish and unpractical, for producing too many clerks, and too few farmers, artisans, technicians, and reliable administrators." [Blaug 1974:46].

The information compiled here indicates that Third World countries, due to poverty, paid no attention to technical education besides the general fact that vocational schools are expensive and that vocational school teachers ought to be well-trained teacher with industrial experience. Most of the Third World countries adhered to certain ideas of famous intellectual, Foster in Blaug [1974:21], for example, argued from Ghanaian evidence that vocational training provided by institutions of formal education could never become an effective method of accelerating economic development. According to him, vocational education is more efficiently provided in practice on the job rather than inside schools. Special vocational institutes can be closely merged with on-the-job training and with actual manpower requirements for skills indicated by the market [Blaug 1974:21].

In this context Foster in Blaug [1974:21] implies that vocational education on a full-time basis must impact specific skills rather than general skills. A good deal of evidence has been forthcoming from other countries that threatens even the slender foundation for vocational school strategy in educational planning of Third World countries.

2.3.1 TECHNICAL EDUCATION IN GHANA

Over a period of hundred years the Ghanaian system of education has continued to emphasise general rather than vocational education. The reason for this might be that throughout the colonial period, there was a relatively greater demand for clerical and commercial employees than for technically trained people [Blaugh 1974:50].

From the 1980's, attempts have been made by missionaries and the government to provide commercial as well as agricultural training to pupils in elementary schools in the Gold Coast. In most of the schools which were receiving grants for manual work, this work constituted agriculture. Before 1909 a number of courses for teachers and students were held at the four agricultural stations in the colony, namely Aburi, Asuantsi, Kumasi and Takwa, in order to assist in the teaching of agriculture. In 1909, the first serious attempt was made to establish a form of technical training and the Accra Technical School was opened. The chief purpose of the school was to produce people who would take charge of the workshops the government had set up. This technical school admitted persons who had attained at least Standard Five and the course lasted for two or three years. This school was later transferred to Takarodi in 1933 to become the nucleus of the present technical school (Graham 1971:154).

In 1922 four junior trade schools were also established, two in Ashanti and two in the Colony. These schools were also expected to meet the growing need for artisans of a reasonable, general educational standard and taught both academic and technical subjects. In the same year, technical classes were introduced for engineering apprentices who were serving under contract with the Gold Coast Railways. These classes were conducted twice a week in one-hour periods. The course lasted five years, and was intended to augment the practical training they had received in the workshop. Among the subjects taught were Practical Mathematics, Engineering and Workshop Practice (Graham 1971:154).

In 1930 the government technical school in Accra continued to marked progress. There were 84 pupils in training, 52 of whom were being trained as carpenters and 32 as metal-workers. The practical training of the carpenters was devoted to joinery and cabinet-making, with instruction in Arithmetic, Geometry and Building Construction. Metal-workers received training in Fitting, Turning and Smithery in addition to Mechanical Drawing, Applied Mechanics and the Theory of Internal Combustion Engines (Graham 1971:159).

The rapid pace of school development in Ghana was arrested by the world economic slump. Missionary effort slackened because of severe cuts in the education budget.

After the 1950's the government technical school in Accra was transformed into a centre for manpower development for the purpose of maintaining political stability, and preserving the African personality. However, the establishment of the Ghana Education Service in 1974 did not overlook the technical aspect of education. As a result, the following courses were offered at junior and senior secondary levels: Electrical Automobile, Building and Agricultural Engineering. Successful technical students from senior secondary level could further their studies at the University of Science and Technology (Asiedu-Akrofi in Fafunwa 1982:106-113).

In the 1980's a small industrial school was set up to teach carpentry, blacksmithing and printing. When he had been a Wesleyan minister in the colony, Rev. Kemp had also tried to re-organise vocational teaching in two day-schools on the Cape Coast and in Accra. Both these schools consisted of an Upper and a Lower Division. In the Upper Division, advanced subjects like Drawing, Singing, Science, Bookkeeping and Industrial Instruction were taught (Graham 1971:121).

In 1982 Kemp further opened a Technical Boarding School, which was arranged in such a way that pupils should spend two half-days a week doing practical work in the workshop. Basel missions, besides their training or artisans, paid serious attention to agriculture and industrial training. The first three years of school were taken up with intensive agricultural and manual instruction.

When pupils entered the higher school, agricultural and industrial teaching continued to play a leading part in their activities. Despite the missionaries' interest in agricultural and industrial training, the product of their school tended to exhibit a clear distaste for manual labour in favour of academic education.

Graham clearly indicates that the financial and prestigeous reward of agricultural and industrial training did not measure up to those derived from academic studies (Graham 1971:122).

Blaug (1974:50) accounts for the above view, when saying that: "Those who criticise the 'irrational' nature of African demands for 'academic' as opposed to 'vocational' education lies precisely in the fact that it is pre-eminently a vocational education providing access to those occupations with the most prestige and most important, the highest pay within the Ghanaian economy."

2.3.2 TECHNICAL EDUCATION IN NIGERIA

According to Wood (1974:130) technical education in Nigeria has its origin in the establishment of the settlement scheme. The scheme was launched in 1960 with an invitation by the Minister of Agriculture and Natural Resources to young persons to offer themselves for admission to a training course at Region's farm institutes "for training of prospective farm settlers". No precise details of the content of the training course were given initially, but it was clearly stated that the trainees would ultimately be set up as farmers and costs involved in this process would have to be refunded by the government. Preference was given to those who had at least obtained a Primary School Certificate.

The training course, as initially planned, was a balanced combination of lectures, demonstrations and practical work. It centred around five main subject groupings:

General Agricultural Science including farm mechanisation, soil conservation and fertility.

Crop husbandry.

Animal husbandry.

Farm management and organization.

General subjects, e.g. General Science, Civics, etc.

By the end of 1968, five farm institutes had been built in the Benue-Plateau State and a further two were in the process of development. The intention was to provide within these establishments a basic training in the improved agriculture for primary school leavers. It was expected that, after completion of training, the farmer trainees would obtain land where they might apply the ideas which they had acquired. There was no intention of using the trainees in a consolidated way in a land-settlement scheme or using them to 'educate' the rural community at large in improved agricultural practices. The scheme was deliberately kept on a modest footing. The numbers to be trained were confined to twenty youths for each course of approximately ten months. Instructors were largely drawn from Agricultural Advisory Services and Christian missions. They were therefore men with fairly humble academic qualifications, but with considerable direct experience of working with Nigerian farmers. These farming institutes consistently emphasized the realistic and practical aspects of training, so that the training course would subsequently be of direct practical value (Wood 1974:150-171).

Technical education had a slow start and developed less quickly than other forms of education in Nigeria. This was partly due to the fact that the voluntary agencies, which pioneered Western education in Nigeria were unable to increase technical education on the same scale as academic education. Other reasons might be that technical education is much more expensive in terms of staff and equipment and that Christian missions were more interested in a native's ability to read the Bible than in his ability to turn screws and prime water-pumps (Fafunwa 1974:195).

However, Ukeje in Fafunwa (1982:216) indicates that the period 1975-80 made special provision for a system of technical education, which was designed to offer more areas of specialisation and to ensure a more comprehensive training programme.

The highest level of technical education in Nigeria is a degree course in Mechanical, Civil, Electrical, Agricultural and Chemical Engineering run by one of the six Nigerian universities. The next level consisted of five tertiary technical colleges. These colleges train at senior technical level and offer two and three-year courses in Secretaryship. Civil, Mechanical and Electrical studies. All these courses lead to intermediate examination diplomas of the appropriate British professional bodies, particularly the City and Guilds Institute of London. Admission to the technical colleges is on the basis of passing the West African Certificate examination or ordinary Certificate of Education (Fafunwa 1974:196).

2.3.3 TECHNICAL EDUCATION IN LESOTHO

Mohapeloa in Fafunwa (1982:154), when discussing technical education in Lesotho, mentions that it was only in 1906 that, as a result of the initiative taken by

Paramount Chief Lerotholi, the government opened an industrial school in Maseru. It was the only government-run institution of this kind in the country. However, the establishment of the school did not signal the strengthening and development of technical education. Most of the money provided for the development of education, was used for the expansion of primary education. Only 2,68 per cent of the total education budget was used for technical education.

In 1961 the Government of Basutoland Protectorate, launched a Food and Nutrition Education Scheme. The fundamental objective of this scheme was to raise the general nutritional level through a programme of intensive nutrition education, associated with various measures, educational and otherwise, to boost the agricultural productivity of the masses, especially in food crops. In accordance with this scheme seven pilot areas were designated for selective treatment in different parts of the country. One of the devices adopted was the establishment of a system of Young Farmers Clubs in the pilot areas. It was therefore necessary that teachers had to be equipped with sufficient technical knowledge of improving agricultural methods in order for them to make a useful contribution to the success workability of the scheme (Wood 1974:108).

By 1967 approximately 30 Young Farmers Clubs had been established with the pilot areas. Evidence of the success of the clubs in arousing interest, both amongst the adult population and amongst the young people in the rural areas, is proved by the fact that there was a spontaneous growth of Young Farmers Clubs outside the pilot areas. These clubs relied heavily on the support of interested members of the adult population, particularly farmers using improved methods. Within the pilot areas, the supervision of the scheme was carried out by the permanent Extension Staff of the Ministry of Agriculture. Like in Nigeria, members of the club were required to obtain a small area of land from their parents on which they might practise particular horticultural techniques, learned through the clubs, in the home environment (Wood 1974:108).

In 1973 Gold Fields of South Africa Limited and the government of the Federal Republic of Germany supported a project to train students in basic engineering. This course would lead to general mechanics and automotive training.

This development was followed by the introduction of new courses in plumbing and sheet metalwork. Consolidated Gold Fields Limited of London co-operated in the upgrading of the instruction that was being given in Carpentry and Joinery, Brickwork and Electrical Installation. Two more courses were introduced in 1976. These were courses in basic Electronics and in Industrial Art Training. In 1977 a commercial training school, for the training of clerks, accountants, copy typists and secretaries was opened. In addition to full-time training, short in-service courses were presented when required by the government or private sector.

In 1978 Lerotholi Technical Institute, which was established in 1906, succeeded in increasing its students' enrolment from 126 in 1974 to 392. This institute, which offers training at both post-JC and post-COSC levels, has experienced a number of interesting developments. It has incorporated the technician training school, formerly under the Ministry of Works, and gives training in Civil Engineering and Draugtsmanship (Mohapeloa in Fafunwa 1982:154-156).

2.3.4 TECHNICAL EDUCATION IN KENYA

According to Fafunwa (1982:133), Kenya, like many African countries, was faced with the problem of unemployed secondary school leavers, and a shortage of both high-level and middle-level skilled manpower. In 1963, there were two technical and three trade schools. Eight secondary schools offered industrial training in workshop practice, for example Carpentry and Metalwork.

In 1966 fifteen other workshops were built and trade schools were upgraded to vocational secondary schools. By 1971 there was a total of eight secondary vocational and four technical high schools. Later one of the technical high schools was converted into a secondary vocational school. The three remaining technical high schools are at Nakuru, Nairobi and Mombasa. The other nine schools later became secondary technical schools. This implies that there were more technical high schools than academic high schools in Kenya. Despite the fact that Kenya has more technical high schools than any of the African countries discussed in this chapter, namely Ghana, Nigeria and Lesotho, Fafunwa mentions that technical education in this country is still in a state of flux. Stable conditions have not been experienced since 1977 and are not expected to materialise in the nearby future. However, Kenya Polytechnic has developed considerably since its establishment as an institution of higher education in 1961, and, along with Mombasa Polytechnic, if offers advanced craft and technical training. The government is conducting a huge project estimated to cost over Shs 38,5 million, to expand technical education in Kenya (Fafunwa 1982:133).

By 1976 there were about thirty schools offering industrial education which are presently being expanded with aid given by the Swedish government. The Canadian government has offered to assist Kenya in this field by building a technical teachers' college. In spite of these and other efforts, the fact that there were only 3 659 students enrolled in technical schools in forms 1-4 in 1974 means that, compared to the total number of students in secondary schools, technical education in Kenya is still in its infancy. Even when one takes into consideration those 2 457 who were enrolled at Kenya Polytechnic in the same year, and the 930 at Mombasa Polytechnic, and the about 6 000 in all the 150 village polytechnics, there is not denying the fact that technical education has grown at a painfully slow pace (Fafunwa 1982:133).

The second and the third lines of diversification of educational opportunities are in business and agriculture. In the light of this, there are those who say that Kenya should not produce more than the available employment opportunities, but it would be more tolerable to err on the side of producing more school-leavers with some marketable technical skills. Technical skills, apart from offering more chances of self-employment, can be exported and when there are more and more people with skills, the country will be forced to find a solution. The situation should, of course, be reviewed and the curriculum reformed on the basis of needs at any particular moment in history (Fafunwa 1982:133).

Without isolating African states from other developing countries as a whole, it should be mentioned that in terms of the need for accelerated economic and social development and of the potential resources available for exploitation, present development efforts in African countries are relatively modest.

Another factor which cannot be over-emphasised is that the development in these countries is continually hampered by the lack of an adequate number of pupils and the quality of technically qualified professionals to implement programmes.

2.4 TECHNICAL EDUCATION IN DEVELOPED COUNTRIES

As far as the pattern of development of technical education in developed countries is concerned, D'Aeth (1975:47) says that developed countries differ just as much from one another in the extent of the development of their system of schooling and economic growth.

Poignant (1973:96) points out that developed countries, unlike under-developed countries, have a specific, distinct system of education for manpower development. This distinction has so far been drawn between secondary vocational education, technical education and higher education.

According to the Unesco classification, higher or third level education is that which follows after the age of 18 or 19, on completing secondary education, that is to say, depending on the country in question, after eleven, twelve or thirteen years of general elementary and secondary education. In practice, the dividing line between higher education and secondary vocational and technical education has never been clearly drawn and, what is more, it varies from country to country according to the organisation of its educational system and its classification for purely administrative purposes.

Poignant (1973:96) further points out that in most developed countries, secondary vocational and technical schools still provide a broad spectrum of technical education which includes:

The training of skilled and semi-skilled workers.

The training of technicians.

The training of senior technicians.

In the recent past, the first two types of training were given, almost exclusively, to trainees who had not entered, or who had not completed full secondary education. This is still the case in most Common Market countries, Sweden and Japan, where students finish these two types of training courses around the age of 18, at the same time as the end of completed secondary education. It is obvious that if inter-country comparisons are to be valid, they must be based on a similar classification of training for the performance of identical economic functions.

The training of senior technical engineers is continued for one, two or even three years beyond the age for the completion of general secondary studies. It also tends in variable proportions in different countries, to be given to trainees who already hold the secondary school-leaving certificate. Poignant feels that, if the UNESCO classfication is adopted, the level of senior technical undoubtedly corresponds to higher studies and should be classed as such. In practice, in a growing number of countries (Belgium, United States, Japan, Sweden, etc.) training of this kind is provided in establishments classified, for administrative purposes, as establishments for higher education. In other countries, on the other hand, it may still be produced in secondary establishments of the technical high school type. In order to apply the UNESCO criterion, part of the enrolments in certain establishments, administratively classify as secondary, should be included in higher education (Poignant 1973:82-83).

Thompson (1981:134) outlines why some countries are more developed than others by using the Manpower Forecasting Approach. His approach simply describes an analysis of the economy's need for skilled manpower, from which a calculation may be made of the quantities, kinds and levels of education required to meet these needs. In his explanation of the Manpower Forecasting Approach, he says that if a country knows that by a particular target date it will require a certain number of people in certain crucial employment categories and it makes certain assumptions about the length and kind of education required for each category, it can, in theory, set about adjustments within the educational system to ensure that the people are available when needed.

The only problem is that Thompson does not apply this theory to any practical situation. However, when D'Aeth (1975:16) mentions that the Republic of China developed into a highly technological country with only limited industrialization and without any foreign investments or skills, one gets the impression that the Manpower Forecasting Approach is relevant or applicable to its development.

2.4.1 TECHNICAL EDUCATION IN ENGLAND

According to Roderick (1978:54) the main agents of technical education throughout the greater part of the nineteenth century were the Mechanics' Institutes. Government intervention was limited, initially due to the fact that its Department of Science and Art, under whose auspices Science classes became widespread throughout the country, was responsible for the disbursement of funds. Further funds were made available as a result of the Technical Instruction Act of 1889 and Local Taxation Act of 1890. Development was piecemeal and relied greatly on voluntary initiative and effort. Until the end of the century, there were no defined lines of demarcation between the various sectors of education. Technical education ranged from higher elementary education on the one hand to advanced technical instruction, trade education and technical processes on the other. The uncertainty and vagueness on the part of its foremost proponents hampered the progress of technical education. As a result, enthusiastic advocates of the above system felt that they would rather reduce themselves to the position of proclaiming the needs of technical education.

Roderick (1978:55) continues to say that, as Britain moved swiftly from a primarily agricultural economy to an industrialised one at the beginning of the nineteenth century, the view prevailed widely that the Industrial Revolution with its specialisation of processes and technological innovations demanded workmen with higher literacy levels than their predecessors. The concern with literacy was matched by a firm belief that in the rapidly changing conditions, the skilled workman would require at least a basic knowledge of the elements of Science.

2.4.1.1 Technical high school education in England

Elements of co-operative vocational education can be found in the system of education for over a hundred years. As early as 1824, an orphanage at Potsdam encouraged boys to learn general trades. It was quite common in England during the nineteenth century for children to work in factories part of the day while attending school. Early in this century college students were supervised by school personnel while they worked on their jobs in the community (Wanat & Snell 1980:3).

Vocational education legislation served as an incentive to many school to start co-operative education programmes. Although some school systems offered programmes much earlier, most schools began their cooperative education programmes in the 1960's. One major reason is that legislation provided funds, which acted as an incentive to start programmes. The Vocational Education Amendments of 1968 in particular, made provision for the funding of co-operative education. Part G of the Act contained a definition that spelled out policies relating to the nature of the training courses, the type of related instruction, and the extent of student supervision required in co-operative education programmes. Co-operative education programmes are offered in various fields of vocational education. These fields are Agricultural Education, Health Occupations, Home Economics, Trade and Industrial Education (Wanat & Snell 1980:9).

Co-operative education programmes in Trade and Industrial Education offers numerous opportunities for employment. This type of industrial education usually encompasses two basic models. One involves a programme where the students are assigned to a daily block of periods in a given workshop for specifics in school instruction. These students are placed directly from their class in the workshop in an on-the-job experience for which they were specifically trained. The other model consists of a period each day of related class instruction for a group of students who are employed in a variety of diversified occupations. These students receive their specific training on the job and are released from school on either a half-day basis or a weekly basis arrangement. The instruction in this programme is individualized to suit the unique needs of each student. Co-operative industrial education offers the following trades and industrial occupational clusters:

Temperature Control cluster
Industrial Energy cluster

Repair cluster
Construction and Maintenance cluster
Mechanics and Maintenance cluster
Electric-Electronic cluster
(Wanat & Snell 1980:12).

Co-operative vocational education, as discussed above, aims at equipping pupils with specific technical skills which the economic and technical world might demand from them. It is gratifying to know that the co-operative vocational programmes discussed, maintain a balance in the relationship between theory and practice. This is achieved by reinforcing what students practise at the place of work with theory in the classroom situation. This provides a concrete and practical basis for learning. As a result new concepts which students learn in the classroom situation, are within the conceptual framework of their experience. This enables them to develop clear concepts about the subject matter presented.

2.4.1.2 **Technical education for industrial artisans**

When technical education was introduced during the nineteenth century, some problems were experienced with workers as far as the learning of skills were concerned. Until late in the century, the skilled worker often lacked the basic educational skills to enable him to benefit from such technical education, which was especially provided to fulfil his needs. Courses intended for the artisans did not attract the anticipated numbers, instead they were attended by clerks, shopkeepers and school teachers. The problems posed by the shortcomings in the preparatory education of artisans were quickly appreciated by the founders of the first Mechanics' Institute, the Edinburg School of Art, established in 1821 (Roderick 1978:54).

The first intervention by the State in technical education in England occurred in 1859 with the establishing of the Department of Science and Art. This department owed its origin to the growing awareness of the possible danger of England losing its industrial supremacy and to the consequent belief that this might be brought about by the absence of any effective system of technical education for industrial artisans. A definition of an artisan, was published in the annual report of the Department. In 1865, for example, artisans included: those in receipt of weekly wages or who supported themselves or their children by manual labour and those paid at longer intervals than a week, but who also supported themselves by manual labour (Roderick 1978:62).

The City and Guilds of London Institute for the Advancement of Technical Education was formally inaugurated on 11 November 1878, with the Prince of Wales as President. The City and Guilds began by taking over, in 1879 the technological examinations of the Society of Art and introducing a system of payment-by-results. Classes were intended for persons engaged in industrial operations, artisans, apprentices, foremen, managers and manufacturers. Students were awarded certificates and prizes on the strength of their results in examinations conducted by the City and Guilds. These were regarded as diplomas of proficiency which enabled operatives to obtain better employment and higher remuneration. Subjects were initially limited to Cotton Manufacture as well as Carriage Building. Later on, in 1885, subjects such as Agriculture, Hygiene, Phonography, Drawing and Carpentry were introduced (Roderick 1978:69).

The City and Guilds did not confine itself to aiding technical classes in local centres. It has been its intention to foster a trade school at Finsburg allied with an advanced institution to be established elsewhere in London. As a result, the first technical college was established at Finsbury in 1881. This was to cater for artisans and act as a feeder for the corresponding advanced College of Applied Science. In addition to establishment of the technical college, day and evening schools were established in Workshop Practice, Applied Science and technical subjects (Roderick 1978:69).

Financing technical education in England, like in most, if not all developing countries, has always been an acute problem. As a result the 1890's in England was a decade in which serious attempts were made to grapple with the problem of formalising technical education and creating for it a secure financial footing. This process began with the setting up of the Royal Commission of Technical Instruction in 1881 under the chairmanship of Bernhard Samuelson. The aim was to enquire into the instruction of industrial classes of certain foreign countries in technical and other subjects, for the purpose of comparing it with that of the corresponding classes in England. One of the most important consequences of the Samuel Commission, was the creation of the National Association for the Promotion of Technical Education. This made possible the establishment of the Technical Instruction Act of 1889 [as amended in 1981]. Technical education was now being sponsored by more than one local agency [Roderick 1978:73].

Graham, when referring to the impact of the industrial revolution on technical education, says that for a century in England, schools of industry had blossomed under the impact of the industrial revolution and the rise of the factory system. As a result, children had been admitted from an early age in England, and had been taught to spin, wind, knit, plait straw, sew, cobble shoes and do gardening jobs [Graham 1971:59].

2.4.1.3 Technical college education in England

Courses in technical colleges may last up to six years and may be full-time, "sandwich", or part-time during the day or in the evening. "Sandwich" courses are those in which periods of full-time study at the college alternate with periods of employment in industry, the periods usually being six months. Such courses usually span at least three years and often four or five. It may be a Diploma or Associateship, awarded by the college itself, or more commonly, one of the National Diplomas or National Certificates which are recognized by the Minister of Education, the Scottish Education Department, and the Ministry of Education in Northern Ireland. The National Diplomas are awarded for the successful completion of part-time courses . National Diplomas and Certificates consist of two grades, namely, Ordinary and Higher. The Higher courses aim at reaching the standard of work required to obtain a university degree in the subject chosen.

National Certificates are awarded in:

- Building
- Chemistry
- Chemistry Applied
- Commerce
- Engineering, Chemical
- Engineering, Civil
- Engineering, Electrical
- Engineering Production
- Metallurgy
- Mining
- Mining Survey
- Naval Architecture
- Physics Applied
- Engineering, Mechanical

National Diplomas are awarded in:

- Building
- Engineering, Electrical
- Mining
- Engineering, Mechanical
- Engineering, Production

In addition to courses for National Diplomas and Certificates and for college diplomas and associateships, many technical colleges conduct courses leading to the examinations of the professional and examining bodies such as the City and Guilds of London Institute, the Royal Society of Arts, the Institution of Mechanical Engineering, etc. Such bodies award Certificates, Licentiateships, Associate Memberships, Graduateship of Followships (Higher Education in the UK 1958:47).

A development was the establishment of the National Council for Technological Awards, which administered a new qualification - the Diploma in Technology (Dip Tech.). Courses for this Diploma started in some technical colleges and the number is growing. The qualification has a standing similar to that of a university degree (Higher Education in UK 1958:47).

Conditions for admission to technical colleges are also very varied. For admission to courses of study for National Certificates and Diplomas at the Ordinary level, candidates in Britain must, as a rule, be at least 16 years old and must either:

- have passed the General Certificate of Education examination at Ordinary level in the subjects appropriated to the equivalent examination in Scotland;

- have completed a full course at a secondary grammar or technical school, or

- have completed a part-time course at an evening institute. (Higher Education in the UK 1958:48).

2.4.2 TECHNICAL EDUCATION IN WEST GERMANY

Technical education in West Germany has a long and distinguished history. It is perhaps because of this that present labour and unemployment difficulties have brought it under attack, not least from among apprentices themselves who continue to bulk large in all training programmes. When West Germany made the switch from an agrarian to an industrial economy in the second half of the nineteenth century, vocational schools, known for more than a century, spread rapidly. Through its Constitution of 1919, the new Republic of Germany becomes the first country in Western Europe to make attendance at an institution for vocational education compulsory for all young workers and apprentices. This compulsory training began not earlier than the end of primary studies (age 15). Boys and girls, choosing to leave school for work, at the age of fifteen were required to continue their studies in a part-time vocational school for a further three to four years. A compulsory minimum of attendance of eight hours per week was expected. This was regarded as the first level of technical education (Mallinson 1981:242-243).

Subjects of a general educational nature were taught, including Mathematics and Civics. The problem of this compulsory technical education can best be judged by the latest figures, which became available in 1973 and which revealed that about eight per cent of school-leavers were involved: 1 300 000 apprentices, 230 000 semi-skilled workers, not party to any apprenticeship contract. Of the 1 300 000 apprentices, 700 000 were in industry, 500 000 in commerce or administration and 100 000 articled to liberal professions. The local chamber of commerce and industry is made responsible for supervising the apprenticeship (Mallinson 1981:242-243).

2.4.2.1 Technical high school education in West Germany

Technical high schools trained skilled and semi-skilled manpower in all sectors (industry, commerce, handcrafts, agriculture, arts and craft, etc.). This training begins not earlier than the end of primarý studies (age 15) and is provided in three types of establishments:

(a) The Berufschulen, which takes boys and girls up to the age of 18 who are apprenticed or are already working, or even those who are not at work and are not receiving full-time education. Courses are for six to twelve hours a week, spread over two days. The aim is to broaden the general knowledge of pupils and to complete the theoretical and practical training received in the firm.

(b) The Berufsfachschulen are full-time schools (thirty to forty hours a week). Courses last one or two years. The great majority of students come directly form Hauptschule. Two-thirds of the pupils are enrolled in commercial schools, generally for girls, the rest in industrial, domestic science and arts and crafts schools.

(c) The Berufsaufbauschulen, or complementary vocational schools have been organised since 1962 for the most gifted pupils of a part-time vocational school. Studies are either part-time for three years or full-time for a year and a half. The level of general education provided is equivalent to that of highly skilled manpower (Poignant 1973:106).

2.4.2.2 Technical college education in West Germany

Technical education at this level provides for the training of highly skilled manpower supervisory grades and middle-executive personnel. Until the

Order of the Prime Ministers of the Länder on 5 July 1968, these schools embodied the old engineering school. In view of their post-secondary level and the stricter entrance conditions, these establishments are now known as Ingenieurakademien (colleges of engineering) and have since that date been included in the higher education system. This level of technical education is provided in various types of establishments:

Schools known as Fachsculen train middle-executives, specialists and technicians for numerous sectors, industrial technicians, agricultural specialists, kindergarten teachers, nurses, commecial executives, factory managers, etc. In the industrial schools (Technikerschulen) more than half of the enrolments are part-time.

Pupils of the Fachsculen are admitted after attending a full-time or part-time vocational school and very often after a certain period of practical experience. Admission is not before 18 years, but very often later. There are three levels of industrial education:

(i) The lower level leads in one or two semesters to the foreman's examination.

(ii) The intermediate level trains technicians in three or four semesters of full-time courses. Evening courses last seven or eight semesters.

(iii) The higher level trains non-university engineers.

There are also higher level Fachschulen specialising in commercial studies and social studies, Agriculture, Seamanship, etc. The average length of courses is two years and six months.

The Fachoberschulen or higher technical level was created under a Convention of 31 October, 1968 completing the Halumburg Convention of 1964; they consist of classes 11 and 12 and lead to certificate giving access to advanced technical school. Training lasts two years for Realschule certificate holders who have not served an apprenticeschip. It is reduced to one year for a certificate holder of the Berufaufbauschule and for Realschule certificate holders who have had some vocational training. Hauptschule certificate holders are admitted after an additional period (10 year) of general studies (Poignant 1973:107-108).

2.4.3 TECHNICAL EDUCATION IN JAPAN

Industrial education in Japan from 1870 to the first half of the 1880's was promoted in close relationship with productive activities in order to satisfy the urgent demand for engineers. It was first implemented in the field of technology by the establishment of the Ministry of Technology in 1871. This Ministry of Technology was to serve as a bureau of controlling factories and new plants, as well as for constructing various types of social overhead capital facilities. The first school of education in technology was inaugurated in 1874, which became the University of Technology in 1877. Prior to the establishment of this school, the Ministry of Technology had already started various programmes of technical education at different places. These programmes were incorporated into the school of technology when it was established [UNESCO 1966:131].

Compulsory schooling ends with the first secondary cycle (shugokko), which gives those who leave school at this stage, some basic preparation for a working or domestic life. The compulsory subjects in this cycle include three hours a week of either Industrial Art or Domestic Science and pupils have the choice of a wide range of optional subjects for three hours a week, some of which are vocational in character (Agriculture, Industry, Commerce, Fisheries, etc.) (Poignant 1973:93).

Training for skilled workers and supervisory grades after compulsory schooling is provided:

In the technical section of the higher secondary cycle of three years.

At higher education level in post-secondary colleges (junior colleges or establishments of the same level).

In addition, five year courses at technical colleges have recently been created, whose curriculum embraces secondary and post-secondary studies.

Technical education in the higher secondary cycle is provided either in establishments providing both technical and general education or in specialised establishments providing technical education in one or more fields. This training is in principle at middle-executive or supervisory level, but in view of the large number of certificates awarded, it must also partly represent the training of highly skilled operatives and clerical workers.

Technical education is either full-time (three years) or part-time (four years) or for certain special subjects, by correspondence. Training programmes cover the following:

Agriculture (farming, stockbreeding, etc.);

Industry (engineering, architecture, etc.);

Commerce, including scientific office organisation and management.

As in the case of the general education sections, admission to the technical sections is by entrance examination.

The Technical Colleges are designed to train highly qualified technicians for industry in five years. These colleges, created in 1962, recruit pupils on leaving the first secondary cycle and give them both a general training and technical specialisation at a level combining that of the second higher secondary cycle and that of the senior technician level for industrial education (Poignant 1973:93-94).

2.5 . TECHNICAL EDUCATION IN SOUTH AFRICA

2.5.1 INTRODUCTION

McKerron (1934:103) points out that from a historical point of view, the discovery of diamonds and gold in the latter half of the nineteenth century changed the pastoral and agricultural way of living in South Africa. Behr (1966:4) sheds more light on this aspect when saying that the discovery of diamonds in the 1980's and gold in the 1880's led to large-scale industrialization and the need for increasing numbers of skilled labourers (artisans and technicians).

McKerron (1934:103) further outlines how large-scale industrialisation affected farming and other sectors by saying that the older inhabitants of the country were ill-equipped to adapt themselves to these new conditions which had developed so suddenly and so surprisingly. Many of them were unable to re-organise their farms on a profitable basis. They could not resort to trekking as easily as they had once done, for land in such large quantities was no longer available. Their only hope lay in more scientific and businesslike farming methods and of that, many were incapable. This gave rise to the need for formal education which would equip inhabitants with the necessary skills for industry, commerce and agriculture.

2.5.2 TECHNICAL EDUCATION TO ADDRESS THE PROBLEMS

Concerning the development of education in the latter half of the nineteenth century, McKerron (1934:104) says that education in South Africa was usually attacked for not leading developments, but rather following them. This was true of industrial and technical education. According to McKerron (1984:104), the genesis of industrial education in South Africa, is not identical with that of technical education. Technical education arose out of the needs of growing industries, while industrial education arose out of a desire to help poor whites. Industrial schools were born out of poverty, misery, depressions, wars and epidemics. They were not sponsored by the industries, but by charitable institutions, such as the Dutch Reformed Church. The instructors were, on the whole, more well-intentioned religious people, than competent technicians.

Industrial education in South Africa has not yet managed to rise above the early stigma of being a desire to help poor whites. One of the major reasons for this is that in the Cape, the industrial schools usually appear in areas where poor whites abound. Up until the outbreak of the Anglo Boer War, at the end of the nineteenth century, industrialism in South Africa was limited to the railways and harbours, the gold and diamond mines, building trades, the printing and milling industries, a few small engineering workshops, and other undertakings which had been started by those who were optimistic as to the future of the country (McKerron 1934:105).

2.5.3 HIGHER TECHNICAL EDUCATION FOR WHITES

Malherbe (1925:211) mentions that education at colleges of higher technical education (today known as technikons) started in South Africa as far back as 1910. The largest technical college in South Africa was established in Durban in Natal in 1914. In 1921, 1 635 students were enrolled at this technical colleges. Its admission of whites from 1910 to 1921 increased by seventy three per cent.

It was not until 1967 that four technical colleges for whites became colleges of advanced technical education (CATES) and offered post-standard 10 education in a broad range of disciplines namely: Biological Studies, Physical Studies, Health Education, Agricultural Science, Commerce and Engineering.

In 1968 two additional technical colleges were upgraded and in 1979 the name was changed to technikons (Shippey 1978:314).

The table below shows the enrolment of white students at college of higher education in South Africa between 1969-1982.

YEAR	TECHNICAL		TOTAL
	MEN	WOMEN	
1969	6 955	162	7 117
1970	8 428	366	8 794
1971	8 643	835	9 478
1972	11 985	1 329	13 314
1973	4 760	44	4 804
1974	4 778	76	4 854
1975	6 264	173	6 437
1976	5 445	179	5 624
1977	6 915	145	7 060
1978	16 035	266	16 301
1979	17 012	293	17 305
1980	12 768	286	13 054
1981	11 249	461	11 710
1982	10 726	793	11 519

Sources: Department of Higher Education (1969-1970); Department of National Education (1972-1984); Department of Statistics (1970-1980); Central Statistical Services (1982-1986).

When the statistics above are analysed, it becomes clear that technical education among whites in South Africa, has a long-standing and well-grounded foundation. Concerning this, Etheredge (1982:8) says that South Africa has a highly developed commercial, industrial and banking sector and its mining industry is a world leader it also has subsistence agriculture.

2.5.4 HIGHER TECHNICAL EDUCATION FOR NON-WHITES

As far as technical education for the other population groups is concerned, the coloureds and Indians have one technikon each. The Peninsula Technikon College, became a CATE in 1972. There are also seven technical colleges for the coloureds. The M.L. Sultan Technical College was established in 1946 and in 1968 it became a CATE. Since 1982 it has catered only for tertiary education (Behr, 1984:287-288). The non-tertiary part, consisting of five schools, was taken over by the Division Indian Education in the Department of Internal Affairs.

The Blacks have two technikons. The Mangosuthu, created in 1979 by a number or large corporations and founded by them (Dept. of Finance, 1985), became fully operational in 1982. The Mabopane East Technikon became operational in 1980 (Vos & Barnard, 1984:101). It was renamed Technikon Northern Transvaal. There are also thirty-six technical colleges, sixteen of them in the National States.

The Advanced Technical Education Amendment Act, No. 84 of 1983, Section 25(1)(3) provides that the subsidy granted to CATE may take into consideration different conditions for different technikons, population groups and courses. According to the Committee of Technikon Principals (1985), this was done in order to provide a quota system in regard to the admission of the non-whites to the white technikons.

Today all technikons in the Republic of South Africa are fully-fledged post-matriculationlevel education institutions, offering professional and career-orientated courses at tertiary level to all races. They offer a variety of courses according to local demand. Technikons offer certificated as well as non-certificated or short-term courses at management and middle-management level, a higher Diploma course and National Diploma in Technology are offered in subjects such as:

Electrical Engineering
Mechanical Engineering
Civil Engineering
Industrial Engineering
Applied Sciences
School Management, etc. (Werner 1983:7).

In the light of the above, it is found that technical education for Blacks started very late when compared with that of Whites in South Africa. As a result, it is still in its infancy. Etheredge (1982:8) points out that the Republic of South Africa is faced with poverty both in rural and urban Black areas and massive unemployment. Although South Africa has a substantial number of highly educated people in professional managerial posts who perform a great variety of skills as complex as any in the world, it nevertheless has alongside millions of people who are illiterate and lacking in skills.

Etheredge (1982:11) further points out that the above situation, is aggravated by the fact that Black universities, which have been established in the last decade or so, have not had any facilities for technical education.

2.5.5 SHORTAGE OF BLACK SKILLED MANPOWER

Organized industries in South Africa are aware of the need for training Black industrial workers in urban areas. In the early 1970's the government was approached to provide suitable training facilities to meet this need. Furthermore, in 1973 the government accepted the recommendations of the Van Zyl Commission and announced plans to establish industrial centres in black residential areas to serve the needs of industry (Stroop 1977: 1). This idea concurs with Swanson's (1966:6) statement that the government must be involved in the policy-making and operation of effective technical education.

In the De Lange Report recommendations of 1981, concerning the system of education that would meet the manpower needs of South Africa, vocational and technical education is emphasized due to lack of Black artisans in South Africa. The Commission itself saw one of its main purposes as addressing this question. The extent of the skill shortage was so great, it is claimed, that it could not be met by the white population which was already fully absorbed in employment, nor by white immigration. Education would have to be revamped, allowing for the education and training of some categories of blacks, if economic growth were to be maintained (HSRC 1981:49). This implied a need to improve the skill and knowledge of the labour force and to accelerate technical education and industrial training programmes, thereby increasing productivity.

It has empirically been found that the percentage of pupils taking Mathematics and Science in Black schools is very low and this problem is compounded by a lack of technical training facilities. Terblanche sketched the racial composition of the technological components in twenty-two companies employing about 28000 workers, which reflects the need for training more blacks in technological manpower as follows:

RACIAL COMPOSITION OF TECHNOLOGICAL COMPONENTS IN TWENTY-TWO COMPANIES

Occupation	Number	Indians	Black	Coloured	White
Engineers	84	1,2	0	4,8	94,0
Technologists	131	0	0	0,8	99,2
Metallurgists	208	4,3	1,4	8,2	86,1
Technicians	1 268	2,6	0,9	11,2	85,3

From the above table it can be deduced that the technological manpower components are predominantly white, which suggests that there is a higher demand for technological manpower in South Africa, since other racial groups, including blacks, still play a minor role (Terblanche 1981:27).

This idea is further supported by the Human Science Research Council in Compass of October (1982:7), when saying that the population and composition of the fast growing occupations, that is those of natural scientists, engineers, metallurgists and technicians, are traditionally dominated by Whites. Since these trends cannot continue without seriously hampering the potential growth rate of approximately 4,5 per cent per annum, training of as many people as possible in the skills is needed. To obtain the necessary recruits, special attention should be given to those groups whose potential has not been fully utilized, namely the Non-Whites.

Kraak (1989:26), in support of the view that there is a shortage of skilled manpower in South Africa, says that during the year 1981 the shortage was most acutely felt in the High Level Manpower (HLM) occupations. These HLM shortages, are considered by bourgeois economic theorists and the state manpower planners to be the most crippling. He further outlines the relationship between the employment-creating class and the unemployment rate. According to him the employment-creating class consists of management and executive as well as professional and highly skilled workers. Other workers are dependent on these two groups for job opportunities. Shortage of skilled manpower places a great burden on managers and the professional group to create job opportunities and this burden will increase, as a result of the more rapid growth of the unskilled groups.

Kraak (1989:33) also says that re-skilling work is another crucial process occurring within the metal industry. Some trades, for example, have become increasingly specialized. Kraak makes an example of a fitter with the advances made in Hydraulics and Pneumatics, he says that fitters have since 1979 been required to study these subjects as part of their training. The trade has thus become more skilled. The same can be said of electricians, particularly in the field of electronics and computerisation.

Botha (1981:88) reports on the same matter that the grave shortage of skilled technical workers among Blacks is caused by the fact that the "technical field of study, as offered by technical departments of comprehensive schools, is not drawing enough pupils of the required standard into technical careers". According to him a contributory factor is that a large number of the general public still consider technical education inferior.

The researcher believes this problem to be acute in most African countries, as has already been pointed out in the discussion of technical education in Ghana (3.1). This further implies that the guidance given in primary schools concerning technical education leaves much to be desired.

2.5.6 TECHNICAL EDUCATION IN THE VAAL TRIANGLE

The Vaal Triangle is situated in the Northern part of the Orange Free State and the Southern part of the Transvaal. It is the triangle formed by three towns, Vereeniging, Vanderbijlpark and Sasolburg and their districts. It is one of the most highly industrialized areas in the Republic of South Africa (Official documents Lekoa Town Council 1987).

In order to meet the demands for Black manpower development by the industries the following institutions were established: one technikon (Vaal Triangle) which admits students of all races for higher technical education, one technical college (Lekoa Technical College), one training centre (Vaal Triangle Training Centre), two comprehensive high schools (Sizanani and Thuto-Tiro) and one technical centre (Sebokeng Technical Centre). Each of these institutions will be discussed in the ensuing paragraphs.

2.5.6.1 **Vaal Triangle Technikon**

In the late fifties, as a result of the phenomenal expansion of industries in the Vaal Triangle, an urgent need was recognised for local facilities to implement technical training at all levels. This occurred at a time when great emphasis was being placed, in the country as a whole, on advanced or post-matriculation education, in order to cope with the growing demand for technical personnel at all levels. Consequently, at the beginning of 1960, the Sasolburg Technical Institute was established. Courses up to diploma level were offered, mainly in Chemical Technology and Instrumentation. Sasol being the main source of students.

Local industrialists and other interested parties approached the Department of Education, Arts and Science (now the Department of Education and Culture), which agreed to establish a new College for Advanced Technical Education in the Vaal Triangle. After consultation it was agreed that the purposes of the college would be best served by a central location. Consequently it was decided to establish the college at Vanderbijlpark. Vesco generously donated the present site of 43 ha. Construction of the new college buildings started in 1964. In 1966 the first principal of the college, Mr. C.A.J. Bornman, was appointed and the first classes commenced in July 1966. By 1967 all advanced classes offered in the Vaal Triangle had been transferred to the new college. The college was officially opened on 22 September 1967 by the then Minister of Education, Arts and Science, the Hon. J. de Klerk. During 1979 the name, College for Advanced Technical Education was changed to "Technikon" and the institution is now known as the Vaal Triangle Technikon.

This technikon offers part-time and full-time courses in different fields of study namely: Engineering, Management, Applied Science, Art and Design, etc. Qualifications in each field of study is determined by the number of years:

NUMBER OF YEARS	COURSE OR DIPLOMA
1	National Certificate
2	National Higher Certificate
3	National Diploma
4	National Higher Diploma
5	Master's Diploma in Technology
6	Laureatus

(General information Vaal Technikon 1987).

Large industries in the Vaal Triangle such as Dorbyl, Iscor, Metal Box, Sasol, AECI, etc. develop their manpower with the aid of this technikon. Besides the technikon, most industries have their own training centres for the semi-skilled and lower management level in order to cope with the shortage of skilled manpower (Official Information Vaal Technikon 1990).

2.5.6.2 Lekoa Technical College

It was officially opened by Dr. G. van N. Viljoen, Minister of Education and Development Aid on 14 March 1986. The college offers theoretical training on a part-time and full-time basis. There are theoretical levels namely: pre-tertiary and tertiary levels.

For admission to the pre-tertiary level, candidates who are in possession of Standard Seven certificates which include Mathematics and Science, may enter the N1 course only after successful completion of an entrance examination. For admission to tertiary level (National Technical Certificate), candidates who are in possession of N3 or an equivalent qualification comprising at least three subjects which are appropriate to the subjects of the course he has chosen to follow at the college.

The National Technical Certificate is awarded on successful completion of at least three subjects selected from the following: Electrical Trade Theory, Plant Operation Theory, Welder's Theory, Motor Trade Theory, etc.

The Lekoa Technical College also offers an intensive career-oriented commercial course for school-leavers and adults. Admission requirements for this course is Standard Eight or Senior Certificate with Afrikaans and English.

The duration of the course is three years full-time or six years part-time. Four subjects from N1 to N3 are taken, three of which are compulsory, namely Office Practice, Communication and Typing, the fourth subject is a choice between Accountancy and Computer Practice (Official document Lekoa Technical College 1987).

2.5.6.3 Vaal Triangle Training Centre

The Vaal Triangle Training Centre is one of nine similar centres in the Republic. There are five centres in the Transvaal, two in the Cape Province and one each in Natal and the Orange Free State. Each of the Group Training Centres has one or more satellite centres.

The centre was opened in January 1976 and the staff at that stage consisted of a principal and two white instructors. The number of courses offered during that year were seven and only 153 Blacks enrolled. Funds for this training centre amounted to R150 000 for buildings and R100 000 for equipment.

The table below shows the number of people enrolled for training from 1977 to 1987:

YEAR	NUMBER TRAINED	YEAR	NUMBER TRAINED
1977	510	1982	1 900
1978	530	1983	1 910
1979	749	1984	2 790
1980	1 530	1985	3 100
1981	1 600	1986	9 600
		1987	8 130

The centre has adequate training facilities which include well-equipped workshops and lecture rooms to train people of all races in various courses as determined by the needs of commerce and industry.

The table below shows courses offered and the duration of training:

COURSE	DURATION
Administration	2 weeks
Building	3-9 weeks
Driving	2 weeks
Mechanical	8 weeks
Welding	4-8 weeks
Domestic servant	3 weeks

The Government pays seventy-five per cent of the fee for the courses offered and the employer pays only twenty-five per cent. This is only applicable to tax-paying institutions and is not applicable to municipalities (Official information, Vaal Training Centre 1988).

2.5.6.4 Comprehensive high schools

The information 'Newsletter' published as a supplement to Educamus in 1990, points out that the Department of Education and Training has a massive programme for the expansion of technical education facilities for Blacks. This can be achieved by opening a new spectrum of training facilities. The main purpose is to equip pupils with technical skills which the economic and technological world might demand from them (Kallaway 1934:14).

The Department of Education and Training's expansion of technical education at secondary level in the Vaal Triangle, started with the opening of technical facilities at Sizanani and Thuto-Tiro Comprehensive High Schools. These schools opened their doors to the first group of technical pupils in 1989. Two other comprehensive schools, one in Sharpeville and another in Zamdela have not yet started with their technical section.

At comprehensive high schools, unlike at technical high schools, the curriculum is purely academic, although it consists of theory and workshop practice.

Non-academic subjects are usually classified under National levels as N1, N2, N3, etc. Subjects offered at the two comprehensive schools (Sizanani and Thuto-Tiro) are mentioned in Chapter 1, paragraph one. However, it is important to mention that each comprehensive school has its own approved curriculum for four trades which include Technical Drawing as a compulsory subject (Official document Lekoa Tech. Col. 1989).

How pupils are selected for admission into the technical field, will form part of this study.

2.5.6.5 Sebokeng Technical Centre

Kallaway (1984:402) states that by 1981, sixteen centres had been established by the Department of Education and Training in urban townships. The purpose of these centres was to introduce Black pupils to elementary technical training, which would lead to their admission to technical high schools where a variety of training skills would be offered.

To meet the industrial and commercial needs in the Vaal Triangle, the Sebokeng Training Centre was opened in 1975 by the Deputy Minister of Bantu Education, Mr. T.N.H. Janson. The objective of opening this centre, was to orientate the Standard Six to Eight pupils of local schools for technical courses (Official document Sebokeng Technical Centre 1988).

Since 1984 the Sebokeng Training Centre has accommodated Standard Four and Five pupils of local schools for orientation programmes. Before Sizanani became a comprehensive school, its Standard Eight pupils attended this centre during their technical subjects periods. Today Sebokeng Technical Centre (no longer named Training Centre) offers classes to Standard Four and Five pupils of the neighbouring primary schools, in the following subjects: Technical Drawing, Metalwork, Bricklaying, Welding and Woodwork (Official document Sebokeng Technical Centre 1988).

The teaching and learning of Technical Drawing as a key subject in Technical Education is the focal point of this study.

2.6 SUMMARY

A short history of technical education has been given in this chapter. The next chapter deals with data pertaining to problems in the teaching and learning of Technical Drawing in Black schools.

CHAPTER 3

THE RESEARCH PROGRAMME

3.1 OVERVIEW

The study is based on the critical evaluation of teaching and learning Technical Drawing in Black schools. The aim of this evaluation is to assess the effectiveness of teaching methods in Technical Drawing and provide possible solutions to the improvement of the situation.

3.2 METHOD OF RESEARCH

According to McNeill (1985:17) a social survey method is defined as one of obtaining large amounts of data, usually in statistical form, from a large number of people in a relatively short time. It has for many years been the most widely used method of social research. It may be explanatory or descriptive, or a combination of both.

McNeill (1985:39) further outlines the advantages of this method of survey as one which is relatively quick and cheap. If it is properly conducted, the results are reliable and representative of a much wider population than the the one directly investigated and the personal influence of the researcher on the results is slight. It further produces data that can easily be expressed in statistical form. This enables one to make a comparison between different groups and populations.

In the light of the above, the descriptive research method was used in order to obtain a general view of teaching methods employed. In this method of research, interviews and observations are used as research techniques. This method was selected for the purpose of:

Describing the nature or form of tuition presently applied in Black schools.

Identifying possible solutions to existing problems.

3.3 THE RESEARCH DESIGN

Grinnel (1984:183) defines a research method as the plan or design for the process of finding a solution to the research problem posed by the investigator. It seeks to provide plans, structures, and strategies of investigations which seek to obtain answers to various research questions. It provides systematic procedures for producing data pertaining to development, modification or expansion of knowledge.

Bailey (1982:32) defines "method" as the research technique or tool used to gather data. He differentiates between methodology and method. The latter is used in social sciences whereas methodology is used in Physical Science with the aid of electron microscopes. Data gathering in the research design is facilitated by the use of public opinion polls.

In order to produce a systematic procedure for producing data, a pilot study was conducted as a first phase of the research project. The main purpose of the pilot study is to determine the relevance of the questionnaire which is used as the instrument in the research. The final phase, conducted after the pilot study, confirmed that the questionnaire was simple and could be used to evaluate the teaching and learning of Technical Drawing in Black schools.

3.4 PILOT STUDY

According to McNeill (1985:31) this stage of questionnaire-based research should never be omitted. In it the researcher tries out the questionnaire on a number of people who are similar to those who will be investigated in the actual research. Any possible problems with the drafting or the lay-out of the questionnaire should appear at this stage and can be corrected before the real investigation starts.

In this study, it was used to provide enough data to make a sound decision on the desirability of continuing with the main investigation. It served as a constructive feedback which enabled the researcher to make changes to some of the questions.

3.5 ANALYSIS OF THE PILOT STUDY ON PUPILS. TEACHERS AND HEADS OF DEPARTMENT

The pattern of responses of the heads of technical departments, teachers and pupils, indicated that the questionnaire was simple. Seven out of ten pupils, that is seventy per cent of the pupils, who were interviewed, felt that the questions were simple, reasonably short with clear illustrations. Four out of five teachers, that is eighty per cent of the teachers who were interviewed, recommended a question based on the continuity between the Technical Drawing syllabus of the primary school (standard five) and that of a first standard in the secondary school (standard six). They had the feeling that discontinuity between the Standard Five and Six syllabi was one of the crucial aspects that hampered better insight into the learning of Technical Drawing in Black schools. The other teachers, that is twenty per cent of the teachers who were interviewed, felt that the questionnaire was adequate and there was no need for additional questions.

All four heads of technical departments, that is one hundred per cent of the heads of technical departments who were interviewed, felt that the questionnaire covered most aspects of the learning and teaching situation of Technical Drawing.

3.5.1 FEEDBACK FROM PUPILS ON THEIR QUESTIONNAIRE

TABLE I

Questions	Response	%	Response	%
Sentence construction	Simple	70	Difficult	30
Terminology used in sentences	Simple	80	Difficult	20
Length of questions	Reasonable	80	Long	20
Illustrations	Clear Understandable	70	Not clear Not understanda=ble	30

The results of the pilot study showed that out of ten pupils of the Sizanani and Thuto-Tiro Comprehensive Schools, seven pupils, that is seventy per cent, identified the questionnaire designed for them as simple, reasonably long, with clear and understandable illustrations.

3.5.2 FEEDBACK FROM TEACHERS ON PUPILS' QUESTIONNAIRE

TABLE 2

Questions	Response	%	Response	%
Sentence construction	Simple	90	Difficult	10
Terminology used in sentences	Simple	80	Difficult	20
Length of questions	Reasonable	90	Long	10
Illustrations	Clear and under= standable	80	Not clear Not understan= dable	20
Addition of questions	Yes	-	No	100

Four of the five teachers, that is eighty per cent of the interviewed teachers, indicated that the pupils' questionnaire was simple and clearly constructed with understandable illustrations. All five teachers, that is one hundred per cent of the interviewed teachers, felt that there was no need for additional questions.

3.5.3 FEEDBACK FROM TEACHERS ON THEIR QUESTIONNAIRE

TABLE 3

Questions	Response	%	Response	%
Sentence construction	Simple	80	Difficult	20
Length of questions	Short	80	Long	20
Terminology	Simple	60	Difficult	40
Scope of questionnaire: Did questions cover most aspects of teaching and learning Technical Drawing	Suggested addition of questions	80	No addition of questions	20

One out of five teachers, that is twenty per cent of the interviewed teachers, felt that the teachers' questionnaire covered most of the necessary aspects and as a result, questions did not need to be added. Eighty per cent of the teachers who were interviewed, suggested the addition of a question on the continuity between the syllabi for Standard Five and Six.

3.5.4 FEEDBACK FROM THE HEADS OF TECHNICAL DEPARTMENTS ON TEACHERS' QUESTIONNAIRE

TABLE 4

Questions	Response	%	Response	%
Sentence construction	Simple	100	Difficult	-
Length of questions	Short	100	Long	-
Terminology	Simple	100	Difficult	-
Scope of questionnaire: Did questions cover most aspects of teaching and learning Technical Drawing	Suggested addition of questions	-	No addition of questions	100

Four heads of technical departments were only shown the teachers' questions after an addition of a question suggested by teachers. All four of them, that is one hundred per cent of the interviewed heads of technical departments felt that the questionnaire was simple and short and did not suggest any addition of other questions.

3.5.5 FEEDBACK FROM THE HEADS OF TECHNICAL DEPARTMENTS ON THEIR QUESTIONNAIRE

TABLE 5

Questions	Response	%	Response	%
Sentence construction	Simple	100	Difficult	-
Length of questions	Short	100	Long	-
Terminology	Simple	100	Difficult	-
Scope of questionnaire: Did questions cover most aspects in the manage= ment and control of technical situation?	Suggested addition of questions	-	No addition of questions	100

All four heads of the technical departments, that is one hundred per cent of the interviewed heads of technical departments, felt that their questionnaire covered most aspects of the management and control of the Technical Drawing situation. As a result, no additional questions were necessary.

3.5.6 FEEDBACK FROM THE HEADS OF TECHNICAL DEPARTMENTS ON OBSERVATION QUESTIONNAIRE (CHECKLIST)

TABLE 6

Questions	Response	%	Response	%
Sentence construction	Simple	100	Difficult	-
Length of questions	Short	100	Long	-
Terminology	Simple	100	Difficult	-
Scope of questionnaire: Did questions cover most aspects in the evaluation of the Technical Drawing situation	Suggested additional questions	-	No additional questions	100

All four heads of technical departments, that is one hundred per cent of the interviewed heads of technical departments felt that the observation checklist covered most key aspects in the evaluation of the Technical Drawing lesson. As a result no addition of other questions was suggested.

3.5.7 FEEDBACK FROM THE RESEARCHER ON OBSERVATION CARRIED OUT IN THE CLASSROOM

TABLE 7

Questions	Response	%	Response	%
Environment and discipline	Up to standard	40	Needs improve= ment	60
Lesson presentation	Up to standard	40	Needs improve= ment	60
Correct representation and illustrations	Up to standard	40	Needs improve=	60

During observation carried out as part of the pilot study, five teachers were visited during the Technical Drawing periods. The teaching environment or Technical Drawing locality, including illustrations and presentation of the lessons of three out of five teachers, that is sixty per cent, reflected that a number of aspects concerning the teaching of Technical Drawing needed improvement.

3.6 FINAL CONSTRUCTION OF THE QUESTIONNAIRE

In paragraph 10 of this chapter, the value of a questionnaire as a research technique in data collection is highlighted.

Through a pilot study, the researcher checked the relevance of his questionnaire concerning the following aspects:

The relevance of the questions to the study goal.

The relevance of the questions to the sample of the population.

The relevance of the questions to the individual respondent.

The relevance of the questions in relation to the theoretical concept of the study.

When the researcher was satisfied with the relevance of the questionnaire to each of the above-mentioned aspects, the final construction of the questionnaire followed. Some of the questions were basically the same for Part A, Part B, Part C and Part D. The reason for this was to ascertain the views of different groups (teachers, pupils, and heads of technical departments) of the population concerning the same aspects.

In the next points (6.1, 6.2, 6.3 and 6.4) the researcher attempts to establish and justify what he intended to achieve by asking each of the questions in the research schedule.

The numbers used in the final construction of the questionnaire for each part correspond to the number used in the research schedule. Questions with related objectives are combined e.g. 1 and 3 or 5 and 9 (See appendix A to D).

3.6.1 Final construction of the teachers' questionnaire

1. Professional and academic qualifications are the criteria according to which the teachers' knowledge of a specific subject can be evaluated as adequate, competent, advanced or inadequate.

   As far as the age of a teacher is concerned, the researcher believes that the younger the teacher is, the more flexible he is to adjust his teaching methods to the level of his pupils. He further believes that younger teachers possess a greater ability to understand certain concepts from the pupils' point of view.

2. Experience in the teaching of Technical Drawing has a major role to play in rounding off ideas of pupils, interpreting syllabi and analysing pupils' problems. But this does not necessarily mean that a teacher who is already above fifty years of age, is a good teacher. His academic and professional qualifications are also important.

3. The building of models by pupils is one way of developing concepts and attaining a higher level of abstraction. Omitting such an activity, especially in lower classes in Technical Drawing, is to overlook a key aspect.

4. A Technical Drawing teacher who deals with any of those key aspects in three or four periods and waits to set questions on them in a test or examination is setting about it in a wrong way. (Part A, question number 4 in Appendix A).

5 & 6 To ascertain the extent to which teachers find difficulties in interpreting the contents of the syllabus.

7. To ascertain whether the teacher knows and understands his pupils' social environment and certain aspects of their everyday life.

8&11 To assess the school in terms of the availability of visual aids which are required in the teaching and learning of Technical Drawing.

9&15 To assess the teacher's commitment to his subject and his ability to take the initiative.

10. To assess whether pupils "live in the world of Technical Drawing", that is whether pupils discuss, see and experience Technical Drawing everywhere in their everyday life.

11. To assess the level of comprehension and communication of the pupils in the language which is used as a medium of instruction. Poor understanding of the language implies poor concept formation.

13. To assess whether teachers are aware that certain pupils are from poor families living in shacks and that asking them to complete drawing work which requires accuracy at home, is to frustrate them, because they might not have a table to work on at home.

14. To highlight the aspect of non-continuity between the Technical Drawing syllabi of Standard Five and Six.

15. To assess whether teachers believe that a one-time acquisition of knowledge of Technical Drawing during their training will be sufficient for the rest of their teaching career.

17&18 To assess whether teachers are aware of the role played by perception in the forming of concepts when teaching Technical Drawing.

19. To assess whether teachers are more concerned about developing their pupils' competence than their ability to form concepts by using all the available resources e.g. mother-tongue instruction where possible.

20&22 To assess whether all teachers are aware of the important aspects of Technical Drawing which need to be emphasized.

21. To assess the awareness of teachers concerning class discipline according to the nature and demands of Technical Drawing.

23. To assess whether the teacher spends more time on explaining concepts or on allowing pupils to practise Technical Drawing by solving problems.

24. To assess the attitude of teachers towards Technical Drawing.

3.6.2 Final construction of the pupils' questionnaire

1. The size of the class, that is the number of pupils in a specific class, determines the teacher's way of imparting knowledge, for example, paying attention to individual pupils is normally impossible in big classes.

2. The age of the pupils forms a framework in which the teacher should interact. Age implies the level of maturity and this determines what should be discussed with pupils.

3. Knowledge of the different ethnic groups that constitute a class, will make it easier for the teacher to link the subject matter to the realities of life experienced by the group concerned. It will also make it possible for the teacher to avoid passing negative remarks concerning ways of life of ethnic groups to which some of the pupils belong.

4. There is a probability that children of more prosperous and professional parents will be more successful at school. The reasons for this is a difference in the way they are brought up.

5&6 The socio-cultural and socio-economic factors of the family outline the following aspects: relationship between parents and children, the way in which they are brought up and experience of the child (quality of his toys, his playmates, etc.). These factors imply the use of different and varied teaching methods.

7&8 To assess the level of abstraction and concept forming which the child already possesses.

9&10 To assess the extent to which pupils can apply or utilize their conceptual frame of reference in the subject.

11. To assess classroom discipline in relation to the demands and nature of Technical Drawing.

12. To assess the amount of independent problem solving which the teacher develops in the pupils. It further aims at assessing whether the teacher is aware of certain socio-economic factors that might affect the quality of work done at home.

13&14 To assess whether pupils have already developed a positive or negative attitude toward Technical Drawing.

15. To assess how important pupils rate the use of visual aids in the teaching and learning of Technical Drawing.

16&18 To assess to what extent pupils relate the subject matter to their everyday life-world.

17. To assess to what extent pupils are acquainted with Technical Drawing terminology.

From question 19 to 24, a comprehensive knowledge of skills and concepts is assessed. Among others, the following can be mentioned:

Concepts which are clearly developed concerning key aspects of Orthographic projection (first angle).

Level of perception and abstraction in problems based on the illustrations.

Concepts concerning different lines, that is, whether pupils understand and are able to differentiate between different types of lines.

3.6.3 Final construction of the observation checklist

1. Classroom environment can be a motivating or demotivating factor in the teaching and learning of Technical Drawing. As a result one cannot talk about teaching and learning contents without referring to the learning environment.

2. The previously acquired knowledge of the pupils provides a frame of concepts upon which new knowledge should be based.

3&7 Concept formation in Technical Drawing is based on observation of the relation between objects. As a result, without the use of visual aids, pupils will not develop any clear concepts. No amount of explanation can form as clear a concept as the use of visual aids.

4. Every subject has its own terminology. Understanding it implies mastering the terminology used in that specific subject.

5. A key aspect in the teaching of Technical Drawing is to present the subject matter in such a way that clear concepts are formed in the minds of pupils. As a result all the resources at a teacher's disposal which can assist in the forming of clear concepts should be used. It is therefore necessary to make use of the mother-tongue as medium of instruction where possible.

6. To assess whether the teacher is aware of the importance of his pupils' conceptual frame of reference as this has a major role to play in the forming of new concepts.

8&10 &11 Pupils develop better concepts about the new subject matter if they are involved in their own development. Pupil involvement among other activities, includes individual attention and group work, which must take the nature and the demands of Technical Drawing into account.

12. Illustrations on the chalkboard manifest the attitude of the teacher towards his subject, and clearly indicate to pupils which aspects are more important than others in all illustrations.

3.6.4 Final construction of the heads of technical departments' questionnaire

1,3 & 5 Age, qualifications and experience. (Refer to point 6.1 of the same chapter.)

2&4 When teachers and their pupils belong to different racial groups it implies that they have a different cultural background, a different conceptual frame of reference, different experiences due to their different lifestyles and a different interpretation of the teaching of Technical Drawing and learning problems associated with it.

6&7 Lack of knowledge of the subject under one's supervision as the head of technical departments, implies that no justice is done when guidance is provided to teachers and pupils.

9. To assess the criteria for admission into technical education.

10. To assess the amount of time which the heads of technical departments allocate to conduct class visits, which will, in turn, show the quality of guidance provided to teachers and pupils.

11. To assess whether criteria for selecting Technical Drawing teachers exists.

12. To assess the heads of technical departments' views concerning the Technical Drawing syllabus and compare them with those of Technical Drawing teachers.

13. To assess the willingness of the heads of technical departments, to give assistance to teachers of Technical Drawing who experience problems related to the teaching of the subject.

14. To assess the awareness of the heads of technical departments concerning the importance of motivation in the teaching and learning of Technical Drawing.

15. To assess schools with reference to the availability of visual aids required to develop clear concepts in the presentation of the subject matter. Their views are compared with those of Technical drawing teachers.

17. To assess the heads of technical departments' commitment to promote clear concepts in the minds of pupils in the teaching and learning of Technical Drawing.

3.7 POPULATION

According to McNeill (1985:32) the term 'population' refers to all those people who could be included in the survey. Gay also defines 'population' within the same context as the group of interest to the researcher, the group to which she or he would like the results of the study to be generalizable (Gay 1981:86).

In this study, the population consisted of all technical education pupils, all Technical Drawing teachers and all the heads of technical department in Sebokeng comprehensive schools. From this population, sixty technical education pupils, ten Technical Drawing teachers and five heads of technical departments were selected. This subset of some predetermined size was selected from all technical education pupils of Sizanani and Thuto-Tiro Comprehensive Schools, by means of sampling.

In this procedure, a 'sample frame' was produced by listing all technical education pupils of the two comprehensive schools separately, using class registers. Numbers were assigned to each list according to the numbers of pupils in each school. These numbers were assigned to names of pupils in each school and then thrown into the containers, out of which thirty numbers assigned to thirty pupils were drawn for Sizanani and thirty numbers assigned to thirty pupils were drawn for Thuto-Tiro.

Bailey, when referring to the advantage of sampling, states that it enables the research to be conducted at a single point in time so that the opinions of all respondents are comparable. It further enables the researcher to keep a low profile (Bailey 1982:88).

All teachers who were involved in the teaching of some form of drawing and heads of technical departments of Sizanani, Thuto-Tiro and Sebokeng Technical Centre formed part of this population.

3.7.1 Background information pertaining to teachers

The teachers' questionnaire required some background information concerning their qualifications, sex, age, teaching experience, etc. The reasons for the necessity of obtaining such background information are given in point 6.1 of the same chapter.

The table below shows the age and sex of Technical Drawing teachers.

TABLE 1

Class Intervals	AGE					SEX		
	21-25	26-30	31-35	36-40	Total	Female	Male	Total
Age frequency	1	2	4	3	10	1	9	10
Age mid-point	23	28	33	38	-	-	-	-
Mid-point X frequency	23	56	132	114	325	-	-	-

Age intervals from 21 years to 30 years.

Age frequency which indicates the class interval of 31 years to 35 years as the highest.

The mean age, for each class interval calculated as the mid-point. The age mid-point is the sum of the two numbers, the lowest and the highest number within the same class interval, divided by two.

The product of the age mid-point and the frequency is calculated.

One teacher is a female while nine are males.

The table below shows the qualifications, home language and experience of Technical Drawing teachers.

TABLE 2

Qualifications		Home language			Experience		
Std. 10 STD (technical)	Std. 10 PTC & OIC	South Sotho	Zulu	Total	Less than 5 years	More than 5 years	Total
7	3	8	2	10	7	3	10

The highest academic qualification of Technical Drawing teachers is standard ten. Seven of them have obtained the Secondary Teachers Diploma in a technical field, which is a three years' training course. Three have obtained a Primary Teachers Certificate, which is a pre-matric, two years' training course and one year Instructor Course in a technical field. Eight of the Technical Drawing teachers speak South Sotho while two of them speak Zulu. Seven of them are novice teachers while three of them have more than five years' teaching experience. However, their teaching experience is in academic subjects only.

3.7.2 Background information pertaining to pupils

The pupils' questionnaire required some background information concerning their age, sex, parents' occupations, home language, home environment and number of family members.

The table below shows the age and sex of the pupil population.

TABLE 3

	AGE						SEX		
Class intervals	12-13	14-15	16-17	18-19	20-21	Total	Male	Female	Total
Age frequency	9	21	16	11	3	60	37	23	60
Age mid-point	12 yrs 5 mths	14 yrs 5 mths	16 yrs 5 mths	17 yrs 5 mths	19 yrs 5 mths	-			
Mid-point X frequency	112.5	305.5	264.0	192.5	58.5	932.5			

Age intervals from 12 years to 21 years.

Age frequency which indicates the class interval of 14 years to 15 years as the highest.

The mean age, for each class interval is calculated as the age mid-point. This age mid-point is the sum of the two numbers within the same class interval divided by two.

There are thirty-seven boys and twenty-three girls.

The table below shows the parents' occupations, home language, home environment and number of family members.

TABLE 4

Parents' occupation			Home language		Home environment			Number of family members				
	Professional	Labourer	S. Sotho	Zulu	4-roomed house	Big house	Shack	4	5	6	7	8+
Frequency	19	41	43	17	24	13	23	1	6	18	32	3

Nineteen pupils' parents work in a professional capacity.

Forty-one pupils' parents are labourers.

Forty-three of the pupils are South Sotho while seventeen of them are Zulu.

Twenty-four of the pupils live in four-roomed houses, thirteen of them live in big houses while twenty-three of them live in Evaton shacks. Among these pupils, one is from a family consisting of four members, six from a family consisting of five members, eighteen from a family consisting of six members, thirty-two from a family consisting of seven members and three from a family consisting of more than eight members.

3.7.3 Background information pertaining to the heads of technical departments

The heads of technical departments' questionnaire required some background information concerning their age, sex, race, qualifications and teaching experience.

The table below shows the age and sex of the heads of technical departments.

TABLE 5

AGE					SEX	
Class interval	26-30	30-35	36-40	Total	Female	Male
Age frequency	1	3	1	5	-	5
Age mid-point	28	33	38	-		
Mid-point X frequency	28	99	38	175		

Age intervals from 26 years to 40 years.

Age frequency which indicates the class interval of 31 years to 35 years as the highest.

The mean age for each class interval is calculated as the age mid-point. This mid-point is the sum of two numbers, the lowest number and the highest number within the same class interval divided by two.

The product of the age mid-point and the frequency is calculated.

All five heads of technical departments are males.

The table below shows the race, qualifications and experience of the heads of technical departments.

TABLE 6

Race		Experience as Technical Drawing teacher			Qualification			Experience as Head of Department		
Black	White	Nil	Less 5 yrs	More 5 yrs	Std 10 Std (Tech)	Std 10 T4	NTC3 Tradesman	Nil	Less 5 yrs	More 5 yrs
2	3	4	1	-	1	1	3	-	5	-

Two Blacks and three Whites are heads of technical departments.

Only one Black head of a technical department has more than five years experience as a Technical Drawing teacher, the rest never taught Technical Drawing, even when employed in another Department of Education.

The highest academic qualification of two Black heads of technical departments is standard ten.

Three White heads of technical departments have obtained a National Technical Certificate which is an academic qualification. Only one of them has obtained a professional qualification as a teacher, the second has qualified as a technician and the third as a tradesman.

All five heads of technical departments have also less than five years experience in the posts.

3.8 PROCEDURES

After the final construction of the questionnaires, the researcher distributed one part of the pupils' questionnares (Part B) to the head of the technical department at one comprehensive school to administer them.

The mailing of questionnaires to the school principals or heads of technical departments was avoided because of the following reasons:

Mailed studies sometimes achieve a low response rate.

Non-verbal behaviour or personal assessments concerning the respondent's social class and other pertinent characteristics would not be noticed, for example, Part A of these studies required information about age and qualifications. These were observed to be sensitive issues where Technical Drawing teachers were concerned.

The questionnaires were administered in four phases.

3.8.1 The first phase, teachers

The first task of every interviewer is to select respondents. In some studies, interviewers are given a list of people to interview. (Tuckman 1972:238).

In this study, the researcher was given names, telephone numbers and addresses of Technical Drawing teachers at Sizanani and Thuto-Tiro Comprehensive Schools including Sebokeng Technical Centre. It was then found that there were only ten Technical Drawing teachers in these three schools. As a result, it was decided to interview each of them. An appointment was arranged with each individual teacher at home, after school, during break or at any convenient time and place for the interview to be conducted.

The questionnaire was then administered by the researcher in the form of a structured interview. In certain questions, respondents were asked to provide reasons that supported their answers or views.

3.8.2 The second phase, pupils

It is preferable to select interviewers who are trained and experienced, but this is often difficult to do. Since the nature of information required from pupils in this study was less personal and less sensitive, it did not require a more skilled interviewer. It was then decided to choose one head of the technical department, the one at Sizanani Comprehensive School, to administer the pupils' questionnaire. The use of a combination of English and the pupils' mother-tongue was a key technique.

It is important to mention that the researcher assisted the head of the technical department at his school with the selection of the sample group. The reason for this was to make sure that a proper sample was drawn in which all pupils in the technical field, stood an equal chance of being selected as a sample.

At another comprehensive school (Thuto-Tiro), the questionnaire was administered by the researcher. The reason for that was to compare the pattern of response of those pupils whose questionnaire was administered by the head of a technical department with the pattern of response of the pupils whose questionnaire was administered by the researcher.

3.8.3 The third phase, observation

The researcher defined the variables in a study and chose a design for measuring selected variables. A measurement scale was drawn up for assigning numerical scores to a particular variable. A few examples of such variables are language usage, accuracy, neatness, dimensioning, pupil involvement, etc.

Observation was administered by the researcher in a real pedagogical situation where the teacher and the pupils interacted with one another on Technical Drawing subject matter.

3.8.4 The fourth phase, the heads of technical departments

In this phase, like in the first phase, the researcher was given names, telephone numbers and addresses of the heads of technical departments by the principals of the three schools mentioned in point 8.1. The problem experienced by the researcher in this regard, was that there were only five heads of technical departments. As a result, it was concluded to interview all of them. An appointment was arranged with each of them, to meet him at home, after school, during break or at any convenient time and place for the interview to be conducted.

The questionnaire was then administered by the researcher in the form of a structured interview. In certain questions, respondents were asked to provide reasons that supported their answers or views.

In order to have access to the schools, permission was obtained from the principals of the schools concerned and from the head office of the Department of Education and Training, for testing to take place during the normal teaching hours. The testing was conducted in the last week of May 1989. The size of the population of sixty pupils, ten teachers and five heads of technical departments was sufficient for the generalization of the situation in the teaching and learning of Technical Drawing in Black schools.

3.9 DESCRIPTION OF RESEARCH INSTRUMENT

In this study, the research instrument was divided into four categories.

PART A

Teachers were observed and interviewed to gain information concerning the following aspects:

Classroom discipline in relation to the nature and demands of Technical Drawing.

The active involvement of pupils during a Technical Drawing lesson.

How they linked up new concepts with the existing conceptual framework of the pupils.

The use of visual aids in lesson presentation.

How important they viewed the Technical Drawing locality.

The quality of their chalkboard illustrations. Such illustrations should promote clear concepts and exemplify Technical Drawing norms such as accuracy, neatness, etc.

PART B

Pupils were interviewed and observed during a Technical Drawing lesson while they were solving certain problems which were part of their questionnaire.

The main pupose was to ascertain the following:

Whether they experienced problems to link up most of the concepts in Technical Drawing with their everyday life-world.

Whether they experienced problems to understand the medium of instruction.

What strategies they had developed to solve Technical Drawing problems.

Their attitude towards Technical Drawing as a school subject.

Through practical involvement, the researcher wanted to establish what concepts pupils had developed concerning each of these aspects:

Third Angle Orthographic projection.

Sectioning of solids.

Three-dimensional representation on a two-dimensional surface.

PART C

This section consists of an observation questionnaire or checklist which was completed by the researcher during the teaching situation. This section is aimed at revealing certain aspects of Part A, like the value of models, Technical Drawing locality and classroom discipline, which teachers claim to be important aspects of their teaching of Technical Drawing. For example, if in Part A the teacher mentioned that he valued the use of models and free interaction of pupils as very important in the teaching of Technical Drawing, then the researcher should be in the position of observing such a fact as a reality.

PART D

The heads of technical departments were interviewed and short discussions held with each of them concerning reasons that supported their views.

Discussions held and interviews conducted centred around the following aspects:

Their attempts to improve the situation of teaching and learning Technical Drawing.

The criteria applied when admitting pupils to technical education.

Their knowledge of the subject and the cultural background of the pupils and teachers.

Their experience as Technical Drawing teachers and as head of a technical department.

3.10 INTERVIEWS

Van Dalen (1979:158) says that many people are more willing to communicate orally than in writing and therefore will provide data more readily and fully in an interview than in a questionnaire. In a face-to-face meeting, an investigator is able to encourage subjects and help them probe more deeply into a problem, particularly an emotionally-laden one. Through respondents' incidental comments and tone of voice, an interviewer acquires information that would not be conveyed in written replies.

In this study, structured interviews were used with the aid of a questionnaire. From a structural point of view, a questionnaire appears to be a series of carefully-worded questions or items on a specific subject, set out on paper and provided with spaces where the respondent can fill in the answer himself, or select the answer by making a "cross" (X) in the appropriate space.

In this study, the questionnaire as a technique in data collection was used in order to probe the respondents' mental development. Using questions and interviews made it possible for the researcher to establish what the person knew (knowledge or information) and what the person liked (value and preferences and what the person thought (attitudes and beliefs). The closed and open-ended questions, as well as in-depth interviews which were used, could establish what experience had been gained and what was occurring at that point in time.

According to Van Dalen (1979:159) such structured interviews are more scientific in nature than unstructured ones, for the standardized approach introduces controls that permit the formulation of scientific generalizations.

In this study, three groups of respondents were interviewed, namely teachers, pupils and heads of technical departments.

3.11 OBSERVATION

Observation is one of the newly developed procedures. It evolved from a technique used in case studies, into an independent procedure involving various techniques used in different phases by the participant observer. It can be used as a procedure when it is used as the major source of data collection and it can be used as a technique, when it supplements other techniques of data collection (Groenewald 1983: 148).

Van Dalen (1979:162), when referring to observation, mentions that, during observational studies, researchers collect data on the current status of entities by watching them and listening to them rather than asking questions about them. He further says that observation may be controlled or uncontrolled, scheduled or unscheduled.

In this study, the researcher planned to observe and collect data related to the nature of the drawing environment, the use of teaching aids and models and the use of mother-tongue phrases during lesson presentation. The researcher further paid special attention to how the teacher attached his concept to the concept of pupils, the involvement of pupils in the lesson, classroom discipline and representation and illustrations on the chalkboard. In order to achieve this, the researcher constructed a checklist and rating scale of aspects to be observed. This checklist also tends to objectify the observation and provide for a uniform classification of data.

Through observation, the researcher can ease himself into situations at an appropriate pace and thereby avoid rebuffs caused by blundering upon delicate situations. Observation is generally the best method to obtain information from impressions and witness feelings that cannot be verbally reported. In this study, observation was carried out in the classroom situation where the teacher i and pupils interacted on Technical Drawing subject matter.

Tuckman (1972:351) views the classroom as the basic unit for the delivery of educational services. As a result, it should be considered as the appropriate educational milieu when the process of teaching and learning is being studied. Moreover, it is the setting in which teacher and learner interact, making both teaching and learning as operational as possible.

In the light of the above, it can therefore be said that the researcher in this study, conducted his observations in the appropriate setting.

3.12 DATA COLLECTION

According to McNeil (1985:36) data can be collected by means of a mail questionnaire or through a face-to-face administered questionnaire. Postal questionnaires are cheap to administer, and can cover very large numbers of people. Face-to-face interviews take time and cost much more in relation to the number of respondents interviewed. There are several issues related to mail questionnaires, the main being the question of the 'response rate' which refers to the number of people who actually complete and return the questionnaire. This is the major drawback of the postal method, where response rates, usually around 30-40 per cent, are lower than face-to-face research which hopes to achieve an 80 per cent or even 100 per cent response.

In this study, data was collected by means of face-to-face interviews and structured or scheduled observation as research instruments. In chapter four it can be seen how the respondents reacted towards the questionnaire.

3.13 LIMITATIONS

The study took place over a relatively short period and covered a limited range of respondents.

The survey covers only three high schools with teachers and heads of technical departments as respondents and two comprehensive high schools with pupils as respondents.

Technical education in Black schools in the Vaal Triangle is still in its infancy. As a result, most pupils have not yet realized its importance as a key subject in technical education. However, the results of this study will hopefully to a large extent, reflect and describe the scope and extent of the problems in the teaching of Technical Drawing in Black schools.

3.14 SUMMARY

This chapter has outlined the research programme of this study. Special attention has been paid to the research design, the research instrument, data-collecting, including some limitations. In the next chapter the research results are outlined.

CHAPTER 4

RESULTS OF THE RESEARCH

4.1 INTRODUCTION

The purpose of this study is to evaluate the teaching and learning of Technical Drawing in Black schools and to provide a possible solution to problems being experienced. In order to achieve this purpose, questionnaires were administered to sixty pupils, concerning their problems in learning and understanding Technical Drawing as a key subject in technical education. Ten Technical Drawing teachers were individually interviewed concerning problems they encountered in the teaching of pupils, syllabus interpretation, shortage of textbooks and teaching aids (wall diagrams and models). The same ten Technical Drawing teachers were later observed during their presentation of Technical Drawing lessons. The main objective there was to find the correlation between aspects which teachers regarded as very important in the teaching of Technical Drawing (discussed in Part A of this study) and what they actually practised in the real teaching situation (discussed as observable facts in Part C of this study).

Five heads of technical departments were also interviewed concerning problems they encountered in the management, motivation and control of Technical Drawing teaching and learning.

The problem of involving a larger group than the above-mentioned in this research project, has been mentioned in Chapter Three under limitations of this study (paragraph 12).

4.2 RESULTS OF TEACHERS' QUESTIONNAIRE

The structured interviews were conducted with teachers as Part A of this study. The results focus on data that relate to the teachers' experience in and awareness of certain aspects, for example the amount of time to devote to certain key areas, like lettering, accuracy, neatness and line work. It further refers to how teachers evaluate certain aspects which contribute to effective teaching or development of clear concepts in Technical Drawing, like clarity and continuity of the syllabi, availability of textbooks and teaching aids and usefulness of the mother-tongue as medium of instruction when driving home concepts and Technical Drawing locality.

The views of the respondents were indicated by means of a cross (X) in the appropriate box as the researcher interviewed them. Their responses range as follows:

70% of the interviewed teachers had less than 5 years' teaching experience.

90% of the interviewed teachers did not allow their pupils to make models from clay or polystyrene.

70% of the interviewed teachers evaluated the Technical Drawing syllabus as not well-defined with clear guidelines.

60% of the interviewed teachers experienced some problems with the interpretation of the syllabus.

80% of the interviewed teachers evaluated their schools as poorly equipped with Technical Drawing teaching aids (wall diagrams and models).

80% of the interviewed teachers thought it was impossible for them to acquire Technical Drawing models and charts for the school.

80% of the interviewed teachers evaluated their schools as poorly equipped with Technical Drawing textbooks.

80% of the interviewed teachers evaluated their pupils' proficiency in English as generally poor.

70% of the interviewed teachers had a 3 years' Teachers Diploma (STD) in a technical field but only 20% of them had specialized in Technical Drawing.

40% of the interviewed teachers still allowed their pupils to finish incomplete Technical Drawing classwork at home.

90% of the interviewed teachers evaluated the continuity between the standard 5 syllabus and standard 6 syllabus as extremely poor.

40% of the interviewed teachers considered themselves responsible for providing their pupils with teaching aids.

60% of teachers interviewed viewed the use of mother tongue during lesson presentation as less important.

80% of the interviewed teachers considered accuracy and neatness in Technical Drawing as the most important aspects.

60% of the interviewed teachers felt that in order that pupils should develop self-confidence, they should not help one another in solving Technical Drawing classwork problems.

40% of the interviewed teachers claimed to spend 12 to 19 minutes on explaining new concepts to pupils.

60% of the interviewed teachers did not teach Technical Drawing, because of a specific interest in the subject, but were forced to do so by certain factors, like a shortage of Technical Drawing teachers and other economic factors, like not being able to obtain a teaching post other than the one allocated to a Technical Drawing teacher.

4.2.1 Grouping of responses to the teachers' questionnaire

The teachers' questionnaire required information on a number of aspects related to the teaching and learning of Technical Drawing as a whole.

These aspects or items of the questionnaire as they appear in appendix A, were categorized or grouped according to certain characteristics namely positive and negative items. They were then set out in tabular form and graphically illustrated. This classification was done in terms of the items or aspect's contribution towards effective teaching and learning of Technical Drawing. The teachers' response to each aspect helped the researcher to classify every item in tabular form under high or low percentage response.

4.2.1.1 **Positive aspects**

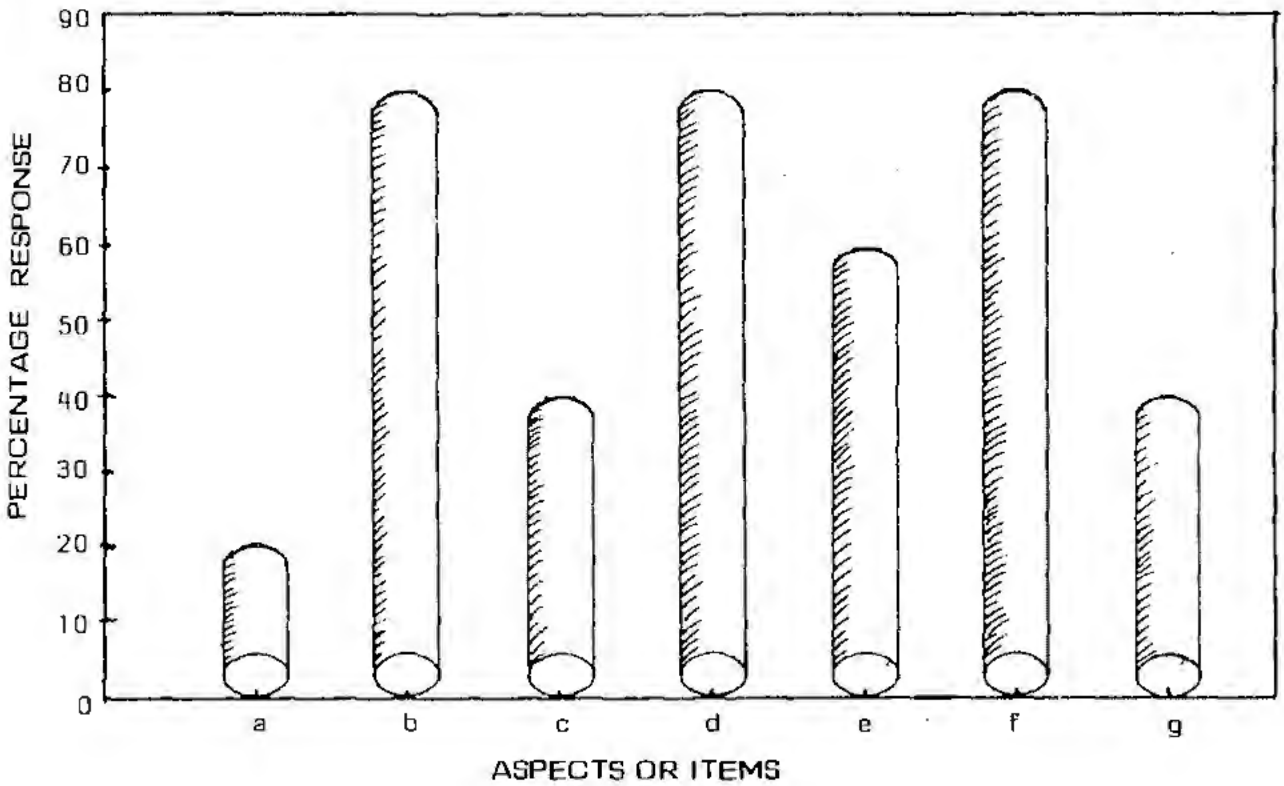
Positive aspects are all the characteristics or items required or needed to facilitate or promote effective learning and teaching.

The table below shows the positive aspects and the percentage response for each item.

TABLE 1

ASPECTS OR ITEMS	RESPONSE
(a) Teachers' qualification with regard to Technical Drawing e.g. STD with Technical Drawing	20%
(b) Attitude towards regular in-service training	80%
(c) Teachers who consider themselves responsible for providing teaching aids	40%
(d) Use of models as important	80%
(e) Well-equipped Technical Drawing locality as educative	50%
(f) Teachers who regard accuracy and neatness most important	80%
(g) Teachers claiming to spend 12 to 19 minutes on explaining new concepts	40%

The graph below represents the information of the positive aspects of Table 1.



The graph above shows the existence of positive aspects among Technical Drawing teachers.

The graph shows that there are three aspects required for effective teaching which eighty per cent of the interviewed Technical Drawing teachers regard as important. It further shows that other important or positive aspects required for effective teaching and learning, are only met by a minority of Technical Drawing teachers. The implication of this is that Technical Drawing teachers regard different aspects as valuable or important in the teaching and learning of their subject.

4.2.1.2 Negative aspects

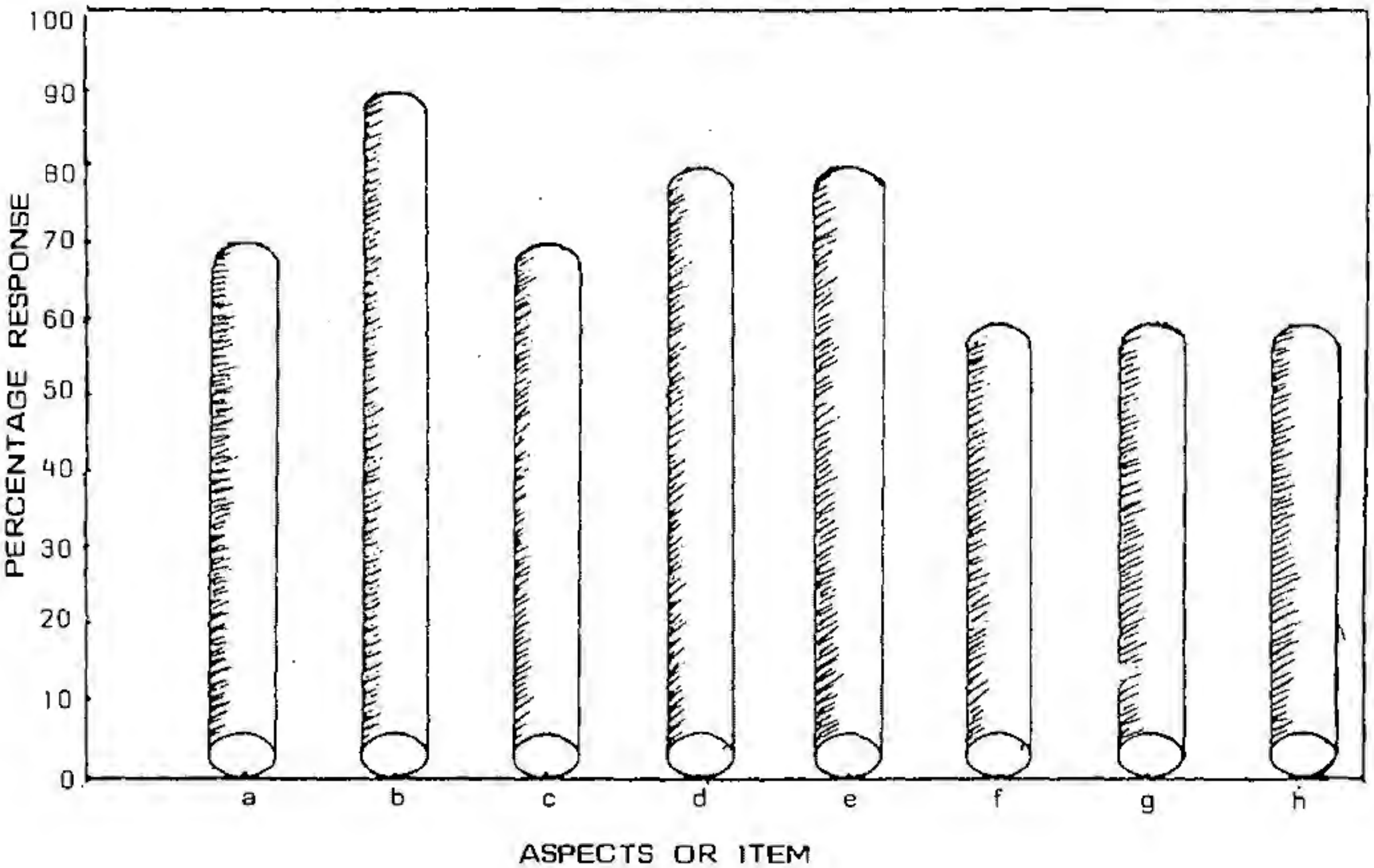
Negative aspects are all the characteristics which obstruct or hinder effective teaching and learning, thus promoting the forming of poor concepts in Technical Drawing. In other words, for Technical Drawing to be successfully taught so that clear concepts can develop in the mind of pupils, these negative aspects must first be removed.

The table below shows the negative aspects or items and percentage response.

TABLE 2

ASPECTS OR ITEMS	RESPONSE
(a) Teachers' lack of experience	70%
(b) Pupils' lack of practice in the making of models for development of abstraction	90%
(c) Poorly defined syllabus contents	70%
(d) School poorly equipped with visual aids and textbooks	80%
(e) Pupils' poor proficiency in English	80%
(f) Lack of interaction among pupils	60%
(g) Problems with the interpretation of the syllabus	60%
(h) Teachers' lack of interest in Technical Drawing	60%

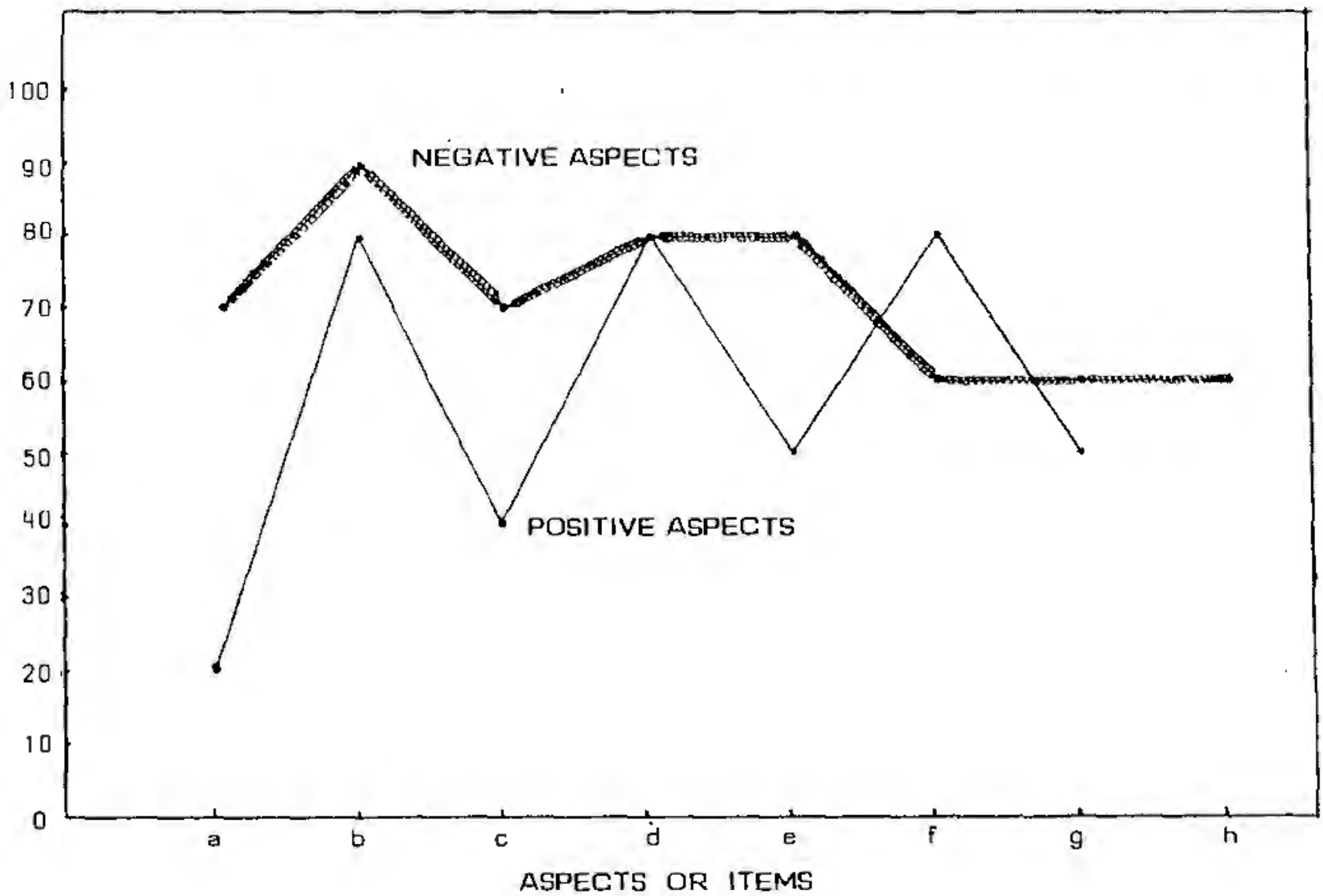
The graph below represents negative aspects which hamper the teaching of Technical Drawing as revealed by the teachers' questionnaire (Table 2).



The graph above shows that there are seven aspects with very high values which hamper the teaching and learning of Technical Drawing, thus affecting the development of clear concepts in the minds of pupils. The group further shows the inter-dependence of these negative aspects: the existence of one aspect affects others. In this respect the teachers' lack of experience which results in their having problems to interpret the syllabus, can be taken as an example.

The graph below shows the combination of both positive and negative aspects in the same plane (Table 1 and 2).

The graph below shows the combination of both positive and negative aspects in the same plane (Tablé 1 and 2).



The graph above shows that there are more negative than positive aspects with a high value and this fact hampers effective teaching. In the situation like the one illustrated above, the possibility of effective teaching is very slim. The reason for this is that aspects which hamper the development of clear concepts are rated higher than those which promote it.

4.3 RESULTS OF PUPILS' QUESTIONNAIRE

The structured interviews and solving of Technical Drawing problems were administered to pupils as Part B of this study. The results focus on data that relate to pupils' problems and attitudes in the learning of Technical Drawing as a key subject in technical education.

The respondents (pupils) indicated by means of a cross (X) in the appropriate box representing their views on each of the following aspects:

Getting Technical Drawing problems right.

Finishing Technical Drawing problems during the allocated period.

Circumstances which promote their understanding of Technical Drawing concepts. freedom of interaction during Technical Drawing lessons.

Relating of Technical Drawing concepts to everyday life and providing technical terms for certain sides of a given figure.

Pupils were further given some problems to solve on first angle orthographic projection, three-dimensional representation on two-dimensional surface, matching of front view lines with the corresponding top view lines and sectioning of a rectangular-based pyramid.

The response of pupils to the questions relating to the above-mentioned aspects is as follows:

68 % of the interviewed pupils' parents were labourers.

The home environment of seventy-eight per cent (78%) of the interviewed pupils was not conducive to learning, for example their having to live in over-crowded four-roomed houses or shacks in slummy areas.

The average Mathematics mark of seventy per cent (70%) of the standard five pupils who were admitted to technical education was above sixty per cent (60%).

80% of the interviewed pupils seldom solved Technical Drawing problems.

80% of the interviewed pupils seldom finished Technical Drawing problems during the allocated period.

70% of the interviewed pupils found most of the concepts in Technical Drawing difficult to understand.

60% of the interviewed pupils said that they were usually permitted to finish incomplete Technical Drawing classwork problems at home.

40% of the interviewed pupils did not like Technical Drawing as a school subject.

60% of the interviewed pupils had problems in relating certain Technical Drawing concepts to their experience in everyday life.

70% of the interviewed pupils were able to give correct Technical Drawing terms for the given illustrations.

70% of the interviewed pupils said that they understood new concepts in Technical Drawing better when visual aids were used.

30% of the interviewed pupils were able to make correct illustrations of a first angle orthographic projection.

30% of the interviewed pupils were able to make correct illustrations of a three-dimensional representation on a two-dimensional surface.

40% of the interviewed pupils were able to correctly match the given front view lines with the given top view lines.

40% of the interviewed pupils were able to make correct illustrations of the top view of the sectioned rectangular-based pyramid.

4.3.1 Grouping of responses to pupils' questionnaire

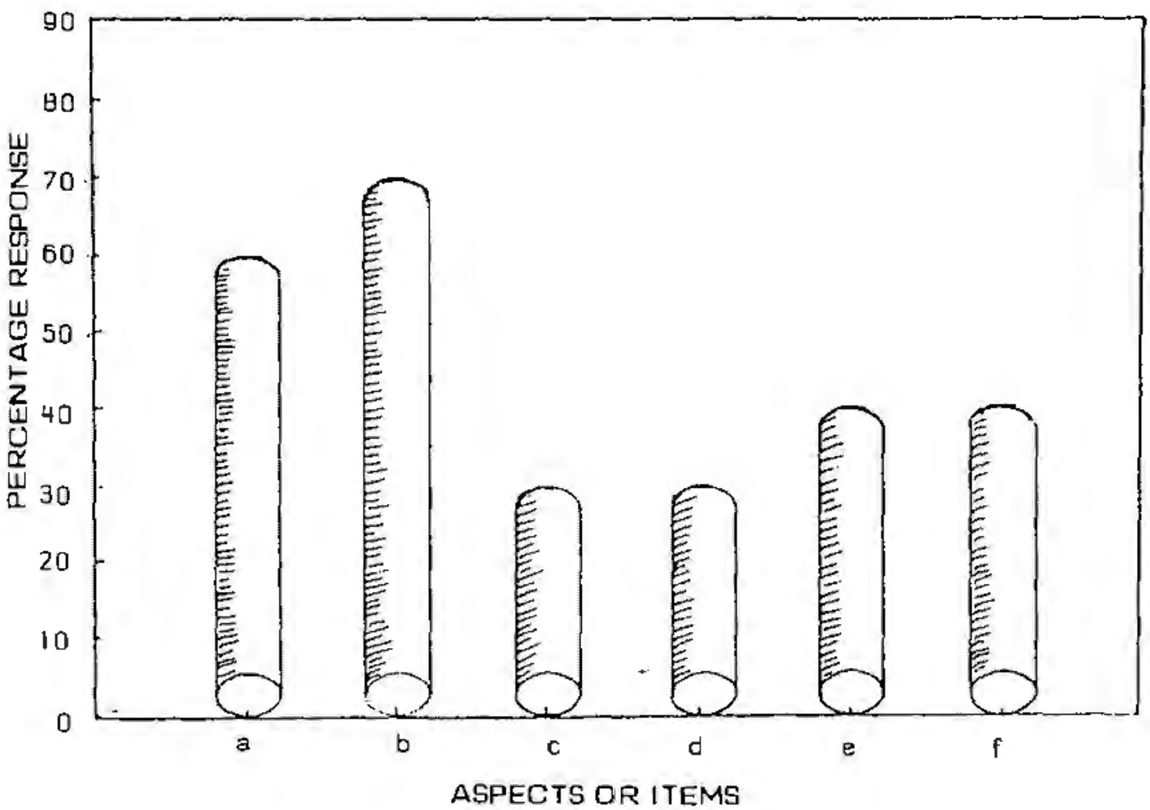
As was done with teachers' questionnaire, the pupils' questionnaire can also be classified in two categories: The one covers those aspects which promote or facilitate effective learning - positive aspects - and the other, those which hamper effective learning - negative aspects.

The table below shows all the positive aspects which need to be developed and the pupils' response to each aspect.

TABLE 3

ASPECT OR ITEMS	RESPONSE
(a) Pupils who did not dislike Technical Drawing	60%
(b) Pupils who were able to give correct Technical Drawing terms for the given illustrations	70%
(c) Correct illustration, First Angle Orthographic	30%
(d) Correct three-dimensional representation	30%
(e) Correct matching of the given front view with the top view	40%
(f) Correct illustration of the sectioned pyramid	40%

The graph below represents positive aspects which need to be developed (Table 3).



The contents of the graph above implies that:

Most pupils do not have a negative attitude towards Technical Drawing as a school subject.

Most pupils have clear concepts about certain aspects of Technical Drawing.

First angle orthographic projection and three-dimensional representation on a two-dimensional surface need some attention.

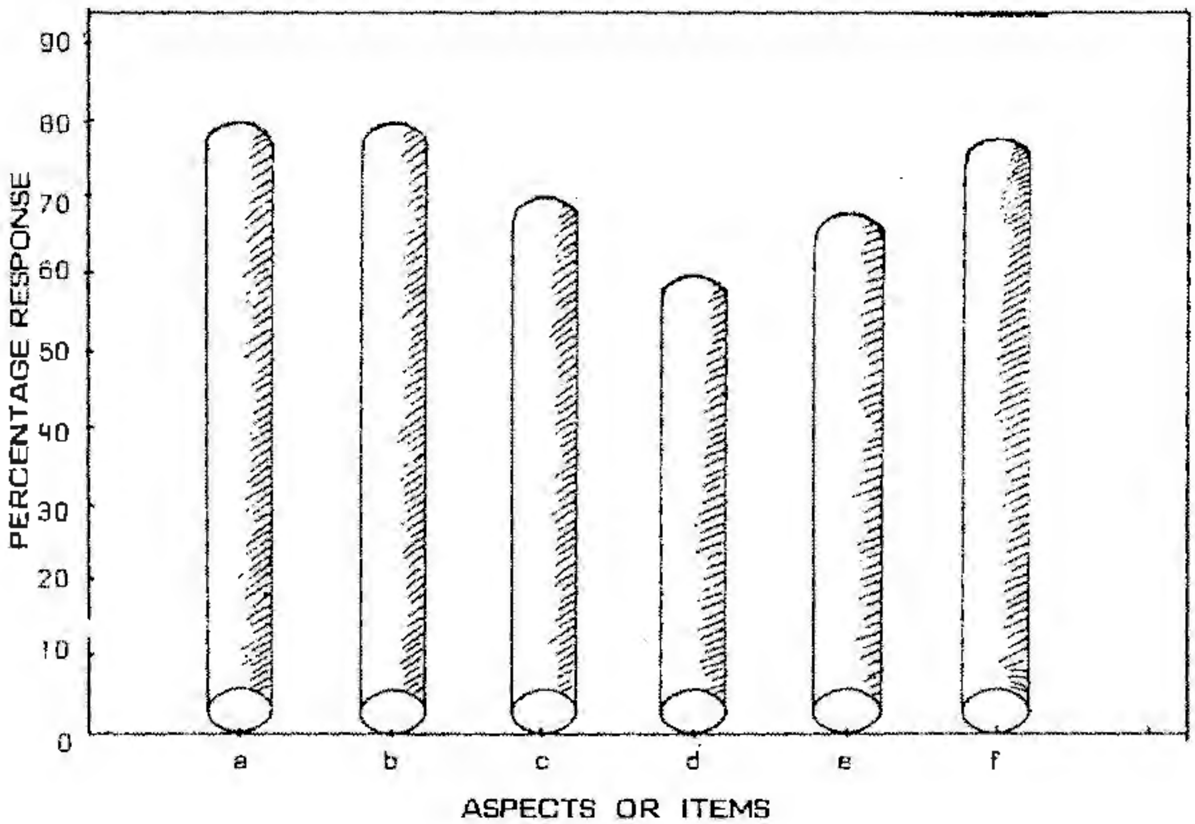
Problems which involve a high level of abstraction need the teachers' attention.

The table below points some of the negative aspects which hamper effective learning, as revealed by the pupils' response to each aspect on the pupils questionnaire.

TABLE 4

ASPECT OF ITEMS	RESPONSE
(a) Pupils seldom solve Technical Drawing problems	80%
(b) Pupils seldom finish Technical Drawing classwork during the allocated period	80%
(c) Pupils find most concepts in Technical Drawing difficult to understand	70%
(d) Pupils have problems in relating Technical Drawing concepts to their everyday life	60%
(e) Pupils' parents are labourers	68%
(f) Pupils' home environment is not conducive to learning	78%

The graph below represents negative aspects which hamper effective learning as revealed by pupils' response (Table 4).

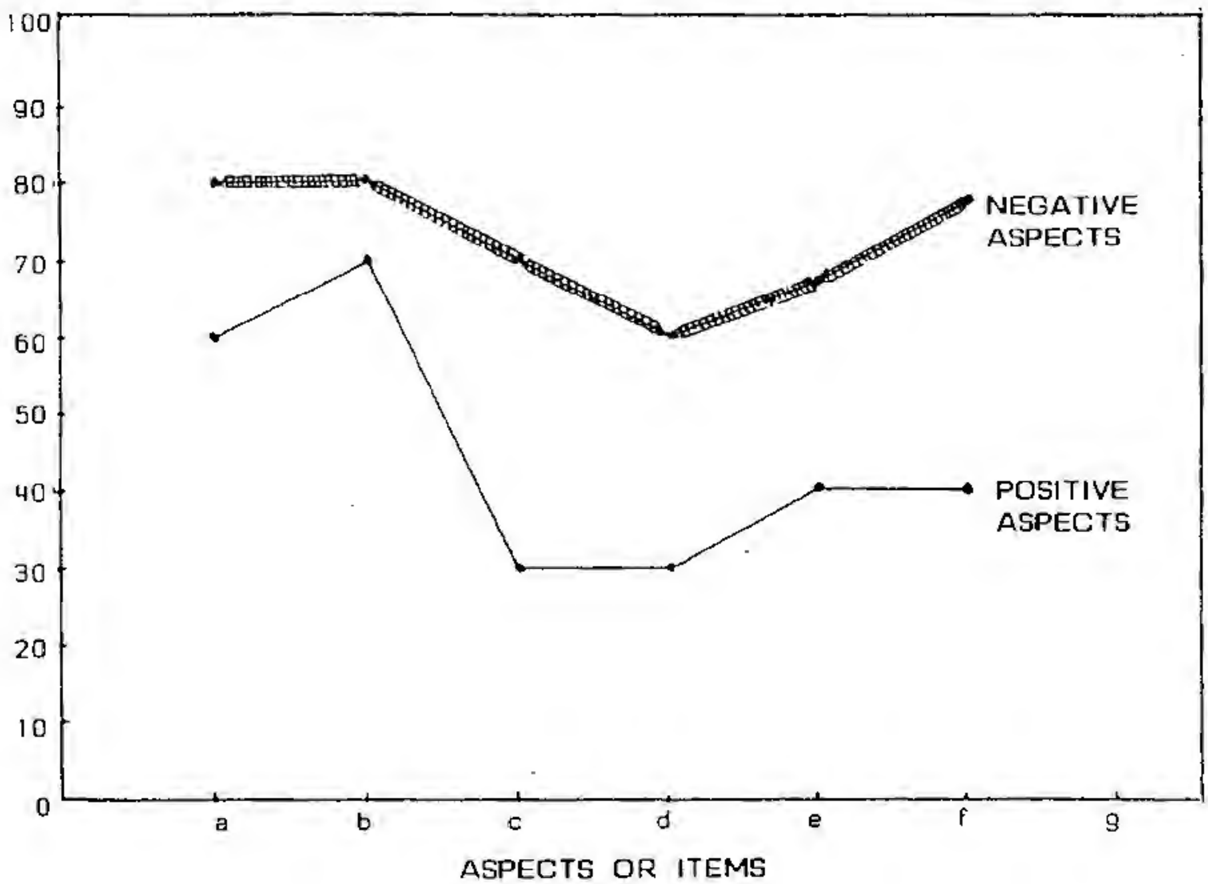


The contents of the graph above implies that:

Pupils lack clear concepts in Technical Drawing as a whole.

Their home environment and upbringing need to be improved, because their domestic background appears to be different from the one which is demanded by the nature of Technical Drawing.

The graph below, shows the rating of positive aspects against the negative aspects in the learning of Technical Drawing (Table 3 and 4).



The graph above shows that all the negative aspects have higher ratings than the positive aspects. The probability of effective learning in such a situation is mentioned in point 2.1.2 of this chapter.

4.3.2 Pupils' Standard Five Mathematics results

The research findings show that the average Mathematics mark of seventy per cent (70%) of the pupils who were admitted to technical education in 1989, was above sixty per cent (60%). The table below (Table 5) shows the Mathematics marks of sixty pupils who were admitted to technical education as follows:

TABLE 5

Class intervals	50-55	56-60	61-65	66-70	71-75	76-80	81 & above	Total
Frequency	6	12	18	10	7	5	2	60
Mid-point	52½	58	63	68	73	78	83	-
Frequency X Mid-point	315	696	1134	680	511	390	166	3892

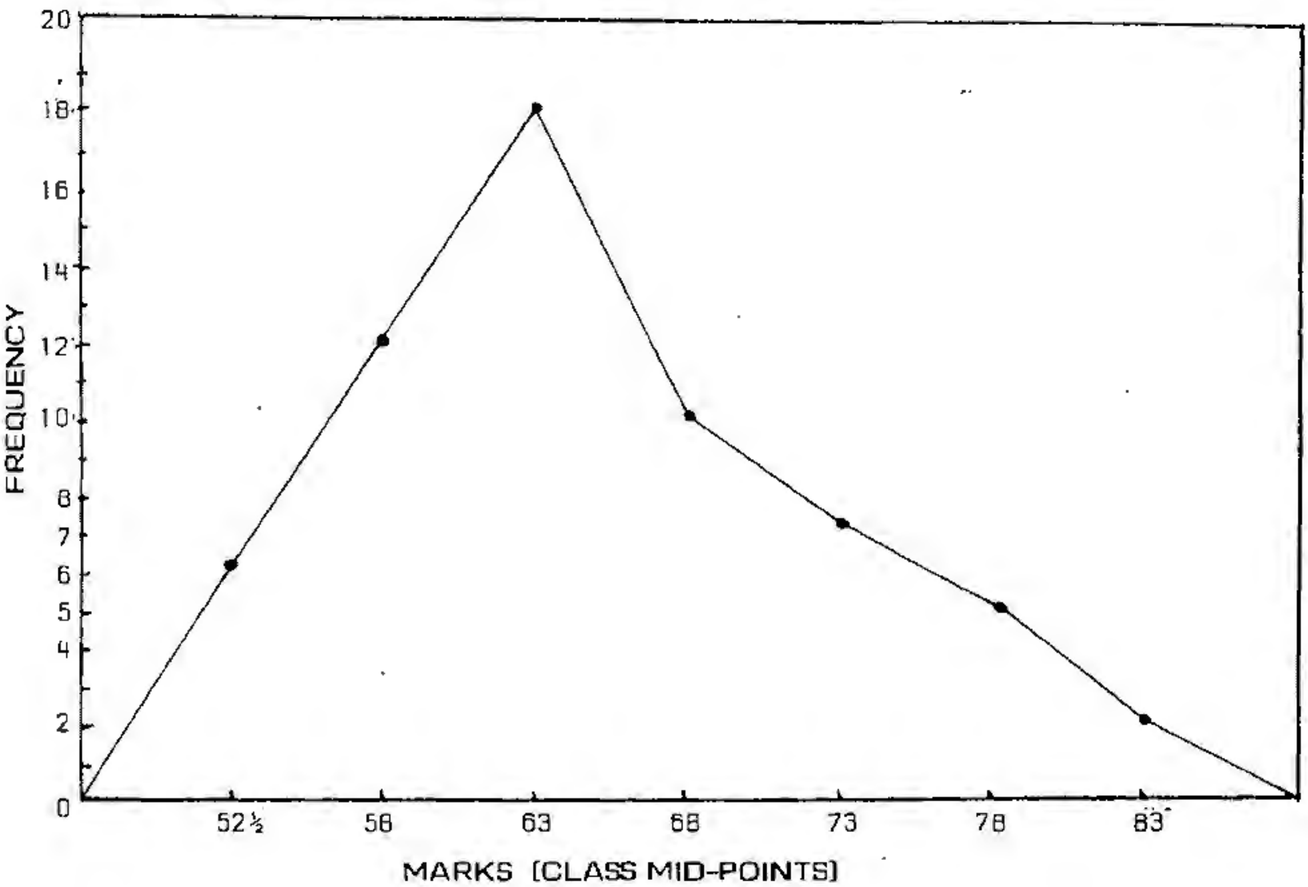
Most of the percentages are in the class interval 61% to 65%. This class interval can therefore be called the modal class.

Frequency refers to the number of pupils whose Mathematics marks fall within the indicated class intervals.

Mid-point is the sum of the highest and lowest numbers with the same class interval divided by two.

The advantage of the mid-point is to give an approximate number to the mean of every class interval.

The graph below shows the contents of table 5, that is Standard Five Mathematics results of sixty pupils admitted to technical education in 1989.



This graph of frequency polygon is drawn by plotting the class mid-points against the frequencies. It shows almost a normal distribution curve, with 18 frequencies as the highest point. On one side of the distribution curve, 6 is the lowest frequency and on the other side 2 is the lowest frequency. This implies that in terms of Mathematical ability, the sample of this study consisted of average, below average and above average pupils.

4.4 RESULTS OF OBSERVATION QUESTIONNAIRE

The observation questionnaire (checklist) was completed during Technical Drawing lessons as Part C of this study. The results focus on data that relate to teaching environment, that is Technical Drawing locality, demonstrations, pupil involvement and classroom discipline in relation to the nature of teaching Technical Drawing.

The researcher indicated by means of a cross (X) in the appropriate box representing the value he thought the observed teacher to be attaching to the above aspects. The results thereof were as follows:

Having observed teachers in action, it was clear that there was a need for improving the classroom environment in order for it to become conducive to Technical Drawing teaching and learning in 70% of the cases.

60% of the observed teachers' use of teaching aids and practical demonstrations needed some improvement.

100% of the observed teachers were capable of using Technical Drawing terminology while presenting lessons.

60% of the observed teachers were not in favour of using the mother-tongue as medium of instruction during explanations to drive home certain concepts.

70% of the observed teachers' way of attaching pupils' concepts to their concepts (teachers' concepts) needed some improvement.

70% of the observed teachers spent more time explaining in an attempt to make new concepts clear and drew very accurate illustrations on the chalkboard.

60% of the observed teachers' classroom discipline in relation to the nature of Technical Drawing needed some improvement.

Pupil involvement needed to be extended beyond the practice of allowing one pupil to make an illustration on the chalkboard while the rest of the class spent more thant twenty minutes of the lesson watching.

70% of the observed teachers were found to be applying the above-mentioned method of pupil involvement. As a result, there is a need for improvement in this aspect. Pupil involvement should be seen as an activity which results in learning.

The neatness of all aspects of classroom and drawing sheets of 80% of the observed teachers was found to be only partly satisfactory.

4.4.1 Grouping of results of observation questionnaire

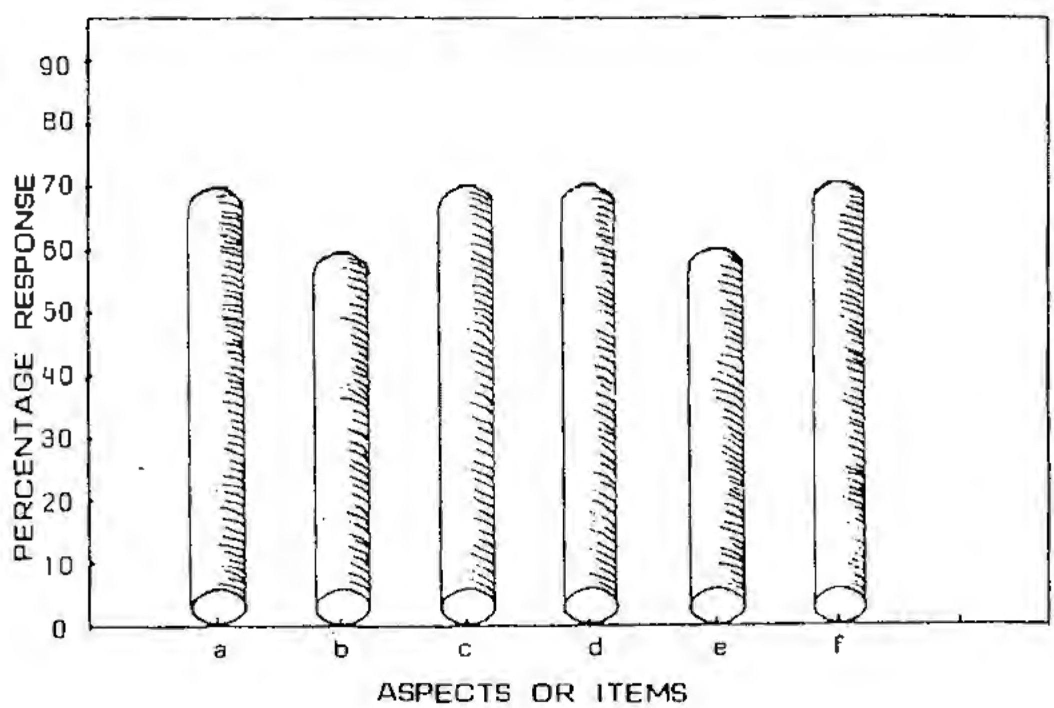
Through observation, two positive aspects which contribute to clear concepts forming in the minds of pupils were evaluated as up to standard in terms of the nature and demands of Technical Drawing. These aspects were: the use of Technical Drawing terminology by teachers during lesson presentation and the neatness of all drawing sheets.

The table below shows six aspects which need to be improved by the indicated percentage of teachers, as observed by the researcher.

TABLE 6

ASPECT OR ITEMS	EVALUATION
(a) Classroom environment [Technical Drawing locality]	70%
(b) Use of teaching aids (visual aids)	60%
(c) The method of attaching new concepts to pupils' conceptual framework	70%
(d) More time spent on explaining new concepts	70%
(e) Classroom discipline	60%
(f) Pupil involvement	70%

In the graph below aspects of table 6 which need some improvement are indicated and the percentage is calculated according to the number of situations observed.



Classroom environment by seventy per cent of the observed teachers.

The use of teaching aids by sixty per cent of the observed teachers.

The method of attaching new concepts to pupils' conceptual framework by seventy per cent of the observed teachers.

Time spent on explaining new concepts by seventy per cent of the observed teachers.

Classroom discipline in terms of the demands and nature of Technical Drawing by sixty per cent of the observed teachers.

Pupil involvement by seventy per cent of the observed teachers.

4.5 RESULTS OF HEADS OF TECHNICAL DEPARTMENTS' QUESTIONNAIRE

The research questionnaire was administered to heads of technical departments as Part D of this study. The results focus on data related to management and control of Technical Drawing as a key subject in technical education.

The views of the respondents were indicated by means of a cross (X) in the appropriate box representing their views as the researcher interviewed them individually. The results were as follows:

60% of the heads of technical departments belonged to another racial group (White).

80% of the heads of technical departments did not have any experience of teaching Technical Drawing.

10% of the heads of technical departments had qualified as professional teachers, the rest could be classified as skilled tradesmen or technicians.

90% of the heads of technical departments did nothing to encourage pupils in the learning of Technical Drawing.

90% of the heads of technical departments believed that teachers had enough Technical Drawing teaching aids and textbooks, simply because the department supplied schools with textbooks and equipment.

70% of the heads of technical departments had done Machine Drawing as a school subject at some stage.

70% of the heads of technical departments enjoyed listening to Technical Drawing lessons.

80% of them reflected that there was nothing of specific interest to them in Technical Drawing.

80% of the heads of technical departments considered Standard Five Mathematics results as important concerning the admission of pupils to technical education.

60% of the heads of technical departments were aware of certain problems which Technical Drawing teachers experienced and were always prepared to discuss such problems with the teachers concerned.

60% of the heads of technical departments considered the criteria for selecting Technical Drawing teachers to be qualifications and interest in the subject.

90% of the heads of technical departments evaluated the Technical Drawing syllabus to be poorly defined with unclear guidelines for inexperienced teachers.

4.5.1 Grouping of results of the heads of technical departments questionnaire

From the results of technical departments' questionnaire, two positive aspects which contribute to solving teachers' and pupils' problems were identified:

Some of the heads of technical departments had experience of some form of drawing, thus enabling them to form an idea about the teaching of Technical Drawing.

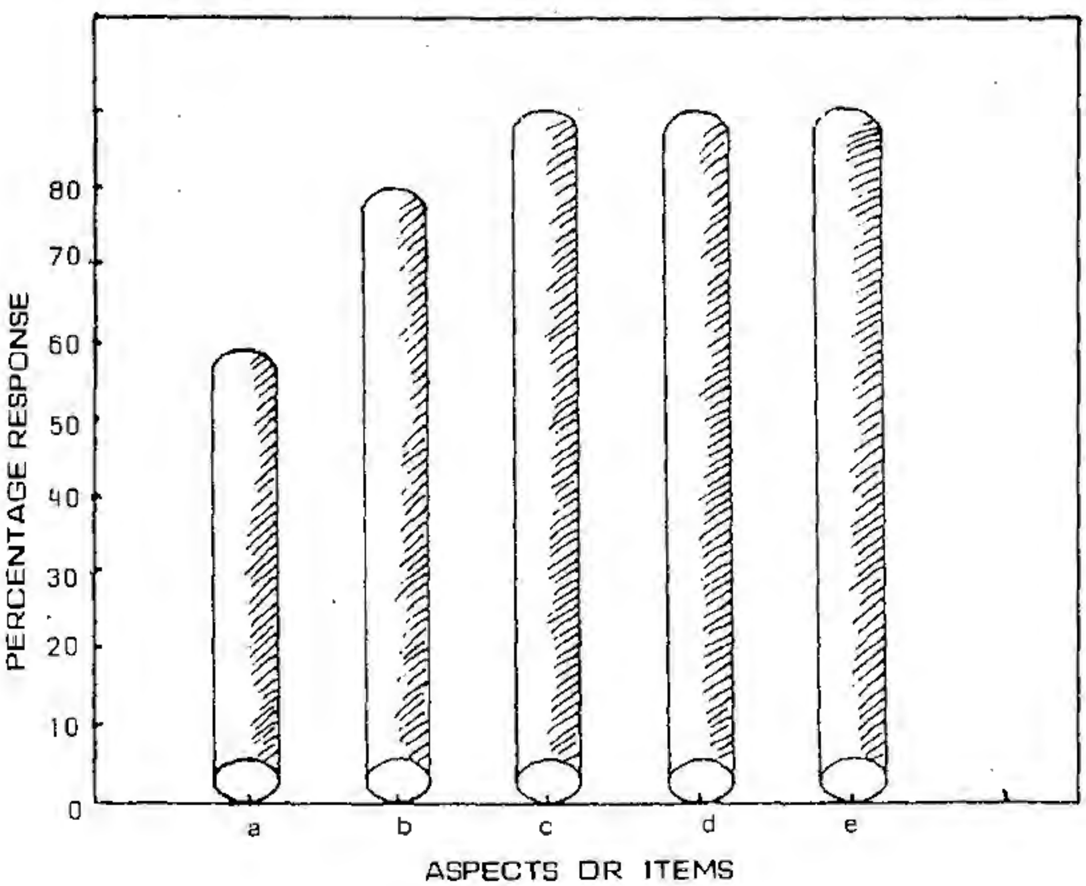
All the heads of technical departments expressed some willingness to discuss problems related to the teaching and learning of Technical Drawing with teachers.

The table below shows aspects which hamper the heads of technical departments:

TABLE 7

ASPECT OR ITEMS	RESPONSE
(a) Most heads of technical departments belong to other racial groups	60%
(b) Lack of experience of heads of technical departments	80%
(c) Lack of professional qualifications as heads of technical departments	90%
(d) Lack of motivation provided by heads of technical department to teachers and pupils	90%
(e) Poorly defined Technical Drawing syllabus	90%

The graph below shows the extent to which certain aspects hamper heads of technical departments in the management and control of Technical Drawing (from table 7).



These aspects which hamper heads of technical department are:

Heads of technical departments belong to racial group different from those of pupils and teachers.

Lack of experience as a Technical Drawing teacher and lack of experience as head of a technical department.

No professional (teaching) qualifications.

Lack of motivation provided to pupils and teachers.

A Technical Drawing syllabus which is poorly defined.

4.6 SUMMARY

This chapter has outlined the results of the questionnaires administered to teachers, pupils, heads of technical departments and the observation checklist. In the next chapter, these results are analysed and interpreted.

CHAPTER 5

RESEARCH FINDINGS

5.1 INTRODUCTION

Before a final research analysis, interpretation and conclusion are made, the main theme of this study will be re-stated. The findings related to this study are discussed in the light of information from literature sources and the conducted research project.

5.2 PROBLEM RESTATED

By means of questionnaires which were administered to the parties concerned and observation conducted by the researcher, an attempt was made to evaluate the teaching and learning of Technical Drawing in Black schools. In other words the questionnaire was implemented in order to probe the dynamic interaction in this teaching phenomenon. The questionnaire consisted of close questions which required a quick response from the respondents. It was therefore necessary for the researcher to hold discussions with these respondents in order to obtain reasons that supported their views.

In this study, a combination of two quantitative research techniques was used, namely, structured interviews, and scheduled observation, because it seemed best suited for the analysis of teaching methods presently applied in Black schools in the teaching and learning of Technical Drawing. The questionnaires were administered in four parts:

Part A for Technical Drawing teachers.

Part B for pupils as learners of Technical Drawing.

Part C for observation to be conducted by the researcher.

Part D for heads of technical departments as managers and controllers of Technical Drawing.

The scope covered by each part is clearly outlined in Chapter Three of this study.

5.3 FINDINGS

With the problem re-stated, namely, a critical evaluation of the teaching and learning of Technical Drawing in Black schools, the researcher now proposes to examine some of the findings of this study so as to arrive at conclusions.

5.3.1 Findings with reference to teachers' questionnaire

Ten questionnaires were completed by teachers responsible for the teaching of Technical Drawing as a key subject in technical education. The inability to have more than ten teachers stems from the fact that technical education as a whole is still in its infancy in Black schools in the Vaal Triangle.

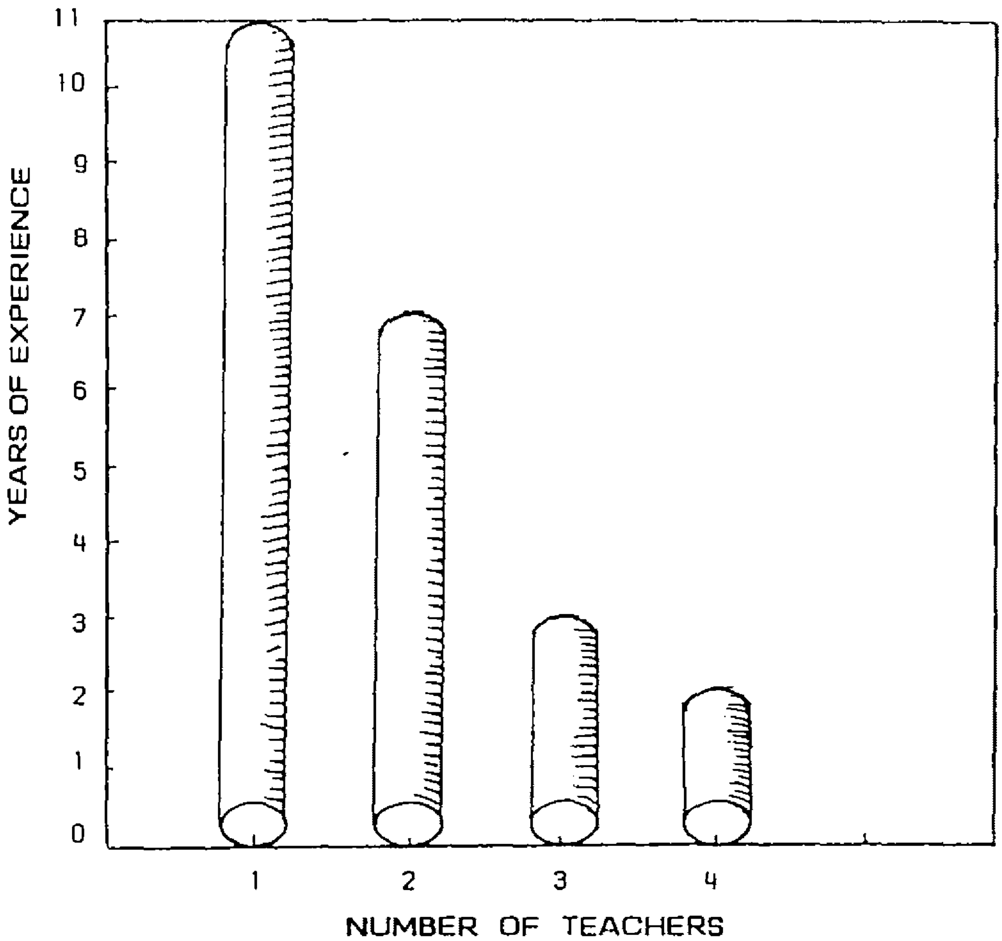
Professional qualifications

It was found that seventy per cent of the interviewed teachers possessed a Secondary Teachers Diploma in a technical field (STD tech.) which is a three years' post-matric training couse, but only two of them had specialized in Technical Drawing as their major subject. The rest had only done some form of drawing, related to their field of specialization for example, those who had majored in civil subjects (carpentry and brickwork), had only done Building Drawing, which is part of the whole sphere of Technical Drawing. They had not done most parts or aspects of Technical Drawing like points and lines, the sectioning of solids, interpenetrations. solids inclination, laminae, cycloidal curves, etc. As a result these teachers were not adequately qualified to teach Technical Drawing.

Practical experience

It was found that seventy per cent of the interviewed teachers had less than five years teaching experience. This implies that Black teachers who are involved in technical education lack practical experience in the teaching of technical subjects as a whole.

The bar graph below indicates the experience of the interviewed teachers in the teaching profession as a whole.



In this regard, it is worth mentioning that teachers' experience in the above graph includes teaching of academic subjects. The graph shows that ten per cent of the interviewed teachers had more than ten years teaching experience, thirty per cent had three years experience and forty per cent had two years teaching experience. This brings the percentage of teachers with less than five years teaching experience to seventy per cent.

In this study, it was observed that pupils intuitively sensed when a teacher was imparting knowledge which was meaningful to him. In other words, pupils appreciated the instruction in Technical Drawing so much the more when the teacher was able to quote from his own as well as from his pupil's conceptual frame of reference. The teacher's realization of how important it is to relate certain Technical Drawing concepts to his pupils' conceptual frame of reference, depends on his personal experience and training.

It can therefore be deduced that practical experience and good training of teachers, will unquestionably encourage them to emphasize the fundamental requirements of correct presentation, accuracy and neatness with the necessary confidence. Without much experience and good training, teachers of Technical Drawing do not have a true conception of the purpose of Technical Drawing. Only experience can bring about this conception. No textbook is able to do it.

This study proves the lack of practical experience to be a key problem in the teaching of Technical Drawing in Black schools. It is therefore not strange that sixty per cent of the Technical Drawing teachers in this study, experienced problems with the interpretation of the syllabus.

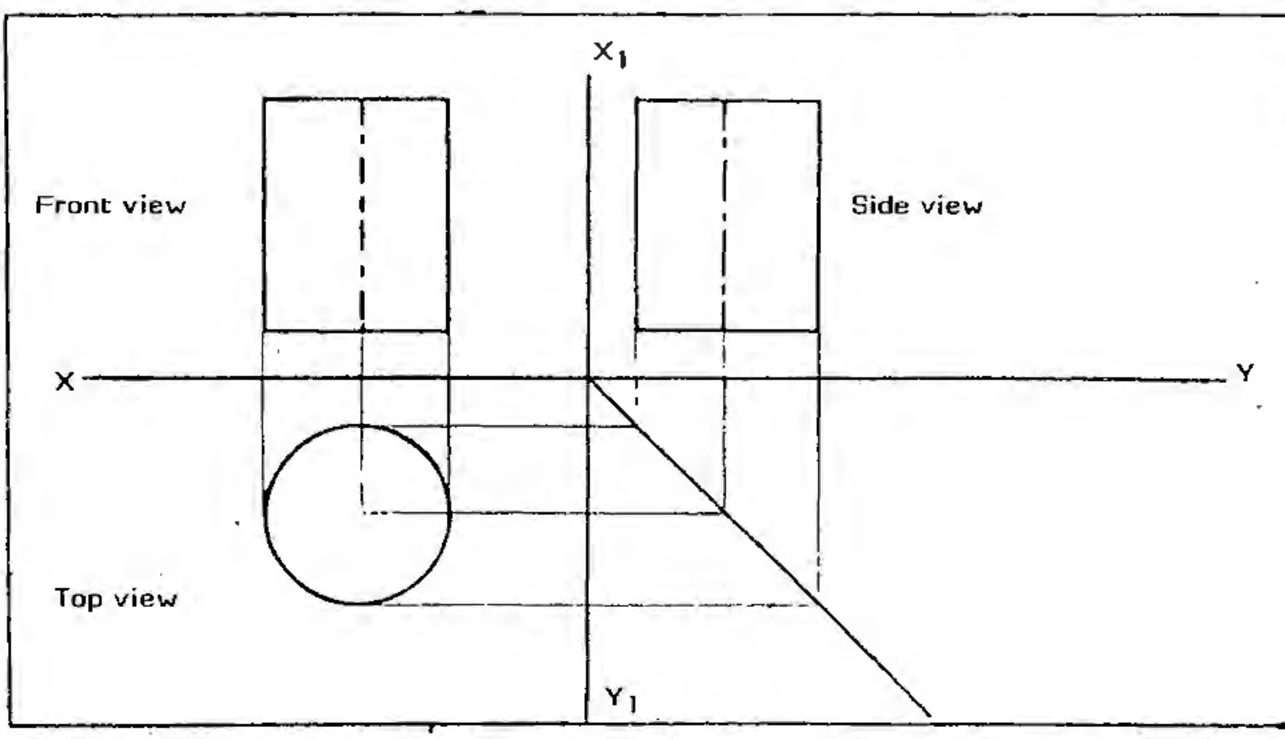
5.3.1.1 Teachers' questionnaire with reference to pupils

Concerning the question of allowing pupils to make models from clay or polystyrene, it was found that ninety per cent of the interviewed teachers had never thought of the possibility at all. In the discussion which the researcher held with these respondents in order to obtain reasons that supported their views, it was found that most teachers thought that instructing pupils to build models was an economic way of gathering teaching aids for the school. Models, according to their point of view, meant ready-made equipment supplied by the Department of Education and Training. As a result they believed that making additional models, when they were about to receive their supply from the Department, would be creating a redundancy.

The above-mentioned view about making models in Technical Drawing explains why sixty per cent of the interviewed teachers did not regard the provision of models and wall diagrams as their own responsibility. This fact once again emphasizes the part played by a lack of practical experience and inadequate training aspects which have already been discussed in paragraph 3.1 of this chapter.

Interviews were held with ten per cent of the Technical Drawing teachers who had more than ten years teaching experience. It was then found that they viewed modelling solid bodies from clay or pure white soap as very important. One of the key reasons that supported their views was that modelling served to convey the pupils' interpretation of an object as represented by a drawing in orthographic projection. To clarify this statement, an illustration will be made.

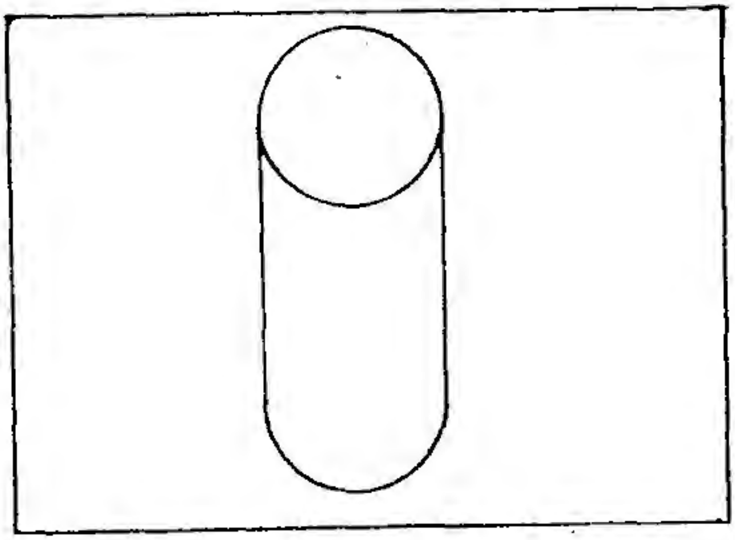
FIGURE 1



The illustration above shows the cylinder represented in orthographic projection.

To test how pupils interpret the object (cylinder) in orthographic projection, they are then asked to make the model of the above object from clay or pure white soap. Those who interpret the illustration correctly will be able to make a model similar to the one represented below (Figure 2).

FIGURE 2



According to the interviewed teachers, this form of testing insight by instructing pupils to make models would immediately reveal any misconceptions or wrong interpretation of the orthographic representation. Wrong interpretation of the orthographic representation, among other things, includes the inability to visualize the relationship between the top view, front view and side view as represented in Figure 1.

From the information gathered in this study, it can be concluded that the making of models has a major role to play in the perception of objects and the formation of concepts. Since most of the interviewed teachers (90%) did not allow their pupils to make models from clay or pure white soap, it is therefore not strange that only thirty per cent of the interviewed pupils were able to illustrate first angle orthographic projection correctly in Part B of this study.

According to eighty per cent of the interviewed teachers, the inability of Black pupils to communicate satisfactorily in English, the medium of instruction, hampers them in the learning of Technical Drawing. It can therefore be concluded that poor concepts are formed in their minds whenever new concepts are presented in this subject. As a result the following requirements are not met:

To bring about change in Black pupils' lives.

To improve their understanding of the reality of their life-world.

To help them give new meaning to their life-world.

To give significance to other situations and subjects.

To form new concepts clearly and correctly.

Concerning the question of solving classwork problems, sixty per cent of the interviewed teachers felt that, in order for pupils to develop skills and self-confidence in problem-solving, they should not help one another. In discussions held with forty per cent of the remaining teachers, it was found that this small number of teachers felt that if pupils were not allowed to help one another in solving classwork problems, then differences in ability, interest and temperament would be neglected. They maintained that intelligent pupils, who had already developed clear concepts about the subject matter, should help their fellow-pupils who encountered problems in Technical Drawing.

5.3.1.2 <u>Teachers' questionnaire with reference to the school</u>

Eighty per cent of the interviewed teachers evaluated their schools as being poorly equipped as far as the availability of textbooks, drawing models and wall diagrams were concerned. This study also proves this aspect to be a key problem. When the researcher was involved in the teaching of

Physical Science, it was experienced that a shortage of models and wall diagrams hampered the teaching and learning of abstract concepts, because pupils were not confronted with concrete realities directly upon their entrance into the classroom. As a result their observation of relations was not developed to the extent where they could visualize some of the most abstract concepts.

From the researcher's practical involvement in the teaching of Mathematics, it was found that a shortage of textbooks did not allow the teacher to take pupils' individual differences into consideration. This implies that the teacher had to make provision for additional problems, which more competent pupils could tackle after completing the given task. Besides providing more competent pupils with additional problems textbooks also contain descriptions of geometrical constructions, certain projection forms and other data of a basic nature, which fade from the memory as new data is acquired. When enough textbooks are available pupils are able to refer to these descriptions whenever necessary.

Eighty per cent of the interviewed teachers evaluated the contents of the syllabus as fragmented and poorly defined, as no clear guidelines exist for inexperienced teachers.

Concerning Part A of this study, the researcher found that teachers revealed a certain degree of dishonesty in the answering of certain questions which could expose their lack of knowledge or inadequacy in teaching Technical Drawing. This fact is exemplified by their response to two questions. The first question asked whether the Technical Drawing syllabus was well-defined with clear guidelines. The second question referred to the possibility of their experiencing problems with the interpretation of the syllabus. Only sixty per cent were honest enough to admit that they did in fact experience problems with the interpretation of the syllabus. Ten per cent who claimed not to be experiencing problems with the interpretation of the syllabus could not provide satisfactory reasons.

5.3.2 Findings with reference to pupils' questionnaire

Sixty questionnaires, including practical involvement of pupils in solving certain Technical Drawing problems, were administered. The findings related to these questionnaires were as follows:

Sixty eight per cent of the interviewed pupils' parents were labourers, which implies that this group of pupils do not receive additional assistance in their school work when they arrive at home. In other words, their parents fail to motivate them with regard to their school work. The key reason for this phenomenon is that most of the time parents are not at home. They leave early for work and come back late, in the evening feeling tired. In most labourers' families the bread winner is unemployed, thus affecting the child emotionally and economically, because during breaks at school, she/he does not have any money to buy something to eat.

Seventy eight per cent of the interviewed pupils came from a home environment which was not conducive to learning. Among other things, there was overcrowding at home. The research findings show that of this seventy eight per cent, forty six per cent belonged to a family of more than eight members who lived in a four-roomed house, while thirty two per cent of them lived in shacks in slummy areas. This phenomenon makes learning at home very difficult. It further implies that the material environment of this group of pupils is very poor in terms of Western standards, and this fact has an influence on their perception.

Seventy per cent of the pupils admitted to technical education scored over sixty per cent in their Standard Five Mathematics examinations. Their average Mathematics mark was 64,8 which was calculated by means of this formula:

$$\text{Mean} = \frac{\text{Total sum of frequency x mid-point}}{\text{Number of items (pupils)}}$$

$$= \frac{3892}{60}$$

$$= \underline{64{,}8}$$

(Chapter 4, paragraph 3.2, table 5)

This implies that pupils admitted to technical education in 1989, possess the ability to learn Technical Drawing. However, it is important to mention that the Standard Five Mathematics paper is not standardized. Every primary school sets its own examination paper. Nevertheless, the information provided in the above type of education, does shed some light on these pupils' Mathematics ability.

Eighty per cent of the interviewed pupils said that they sometimes solved the problems and sometimes finished them during the allocated periods. It can therefore be deduced that pupils lack clear concepts in Technical Drawing.

Seventy per cent of the pupils confirmed that they experienced problems in understanding Technical Drawing concepts. In the same category, sixty per cent of the pupils confirmed that they understood new concepts in Technical Drawing better when models and other teaching aids were used. It is therefore not strange to have such a high percentage of pupils who encounter problems in understanding new concepts in Technical Drawing. The reason for this phenomenon is that in Part A of this study, eighty per cent of the interviewed teachers evaluated their pupils' ability to communicate in English as poor and their schools as poorly equipped with teaching aids which could be used to promote clear concepts in the minds of pupils.

Only forty per cent of the interviewed pupils said that they did not like Technical Drawing as a school subject. In an interview with these pupils, conducted by the researcher to discover the reasons that caused them to dislike Technical Drawing, it was found that they did not realize that they would eventually be able to put the knowledge they were acquiring into practice in their chosen careers.

In this respect the researcher believes that if the subject matter being taught does not address the interest of the pupils, many of them will probably leave school totally disinterested in what they have learned, because they have been unable to link their acquired knowledge to realities they experience in their life-world.

Seventy per cent of the pupils appeared to have no problem with the use of correct technical terms in questions where they were required to use Technical Drawing terminology. It can therefore be deduced that Black pupils do not experience any problems in memorizing terms and reproducing them when required to do so. This implies that Black pupils cope better with rote-learning at the expense of learning with insight.

5.3.2.1 Practical problems : Orthographic projection

In this study pupils were given problems to illustrate. In the first problem they had to illustrate the first angle orthographic projection of a house in isometric drawing. Seventy per cent of the pupils experienced different problems concerning illustration, such as: correct position on the front view, top view and side view, correct dimensioning and clear distinction between the plane lines (horizontal plane - HP, vertical plane - VP).

The researcher believes that these differences in pupils' mistakes are linked to a number of complicated aspects which can be related to their poor mental development, inadequate development of concepts (as a result of the language problem), background problems, and, above all, lack of concept teaching.

5.3.2.1.1 Pupils' problems : Orthographic projection

Pupils were unable to visualize images of elevations projected on the three supporting main planes. As a result, the following aspects could not be visualized by pupils:

5.3.2.1.1.1 Front view

The top side of the two windows and a door form a straight line (line AC). The bottom sides of the two windows also form a straight line (line DE). (See Figure 3.)

5.3.2.1.1.2 Top view

The top view of the pitched roof is not one rectangular figure, but two adjacent rectangles of the same size. This means that the top view of the pitched rectangular roof must have a line in the middle. (See Figure 3.)

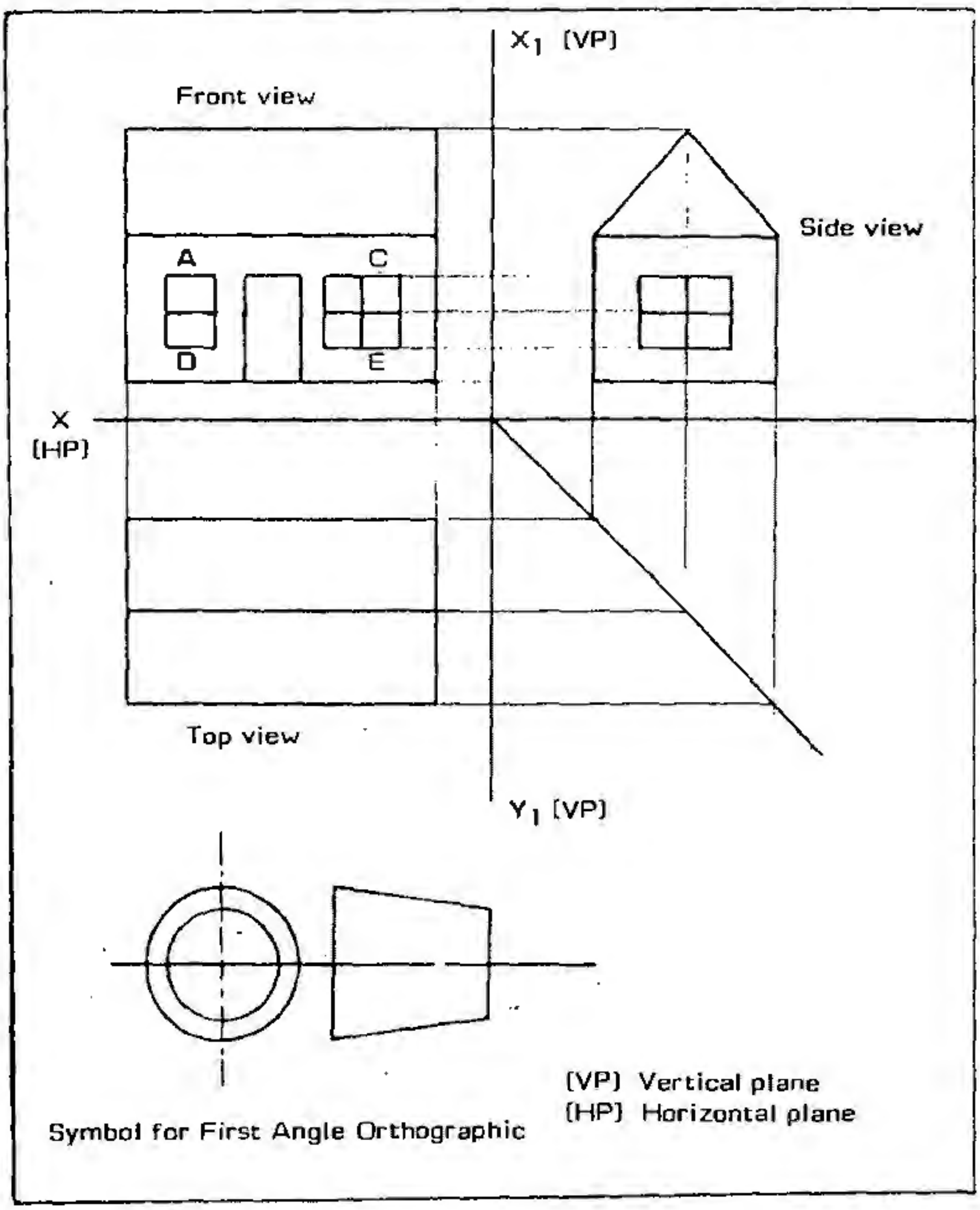
5.3.2.1.1.3 Side view

The bottom and the top level of the front view windows must be on the same level with the top and bottom level of the side view window. The pitched height of the side view must correspond to the pitched level of the front view. This can only be achieved if the importance of construction lines is taken into consideration in the illustrations.

In addition to the above-mentioned aspects concerning pupils' problems, it was found that pupils' illustrations were of different sizes even though dimensions were given. This aspect will be discussed further when it appears in other illustrations that follow thereafter.

5.3.2.1.2 Correct illustration : First Angle Orthographic projection

FIGURE 3



5.3.3 Three-dimensional representation

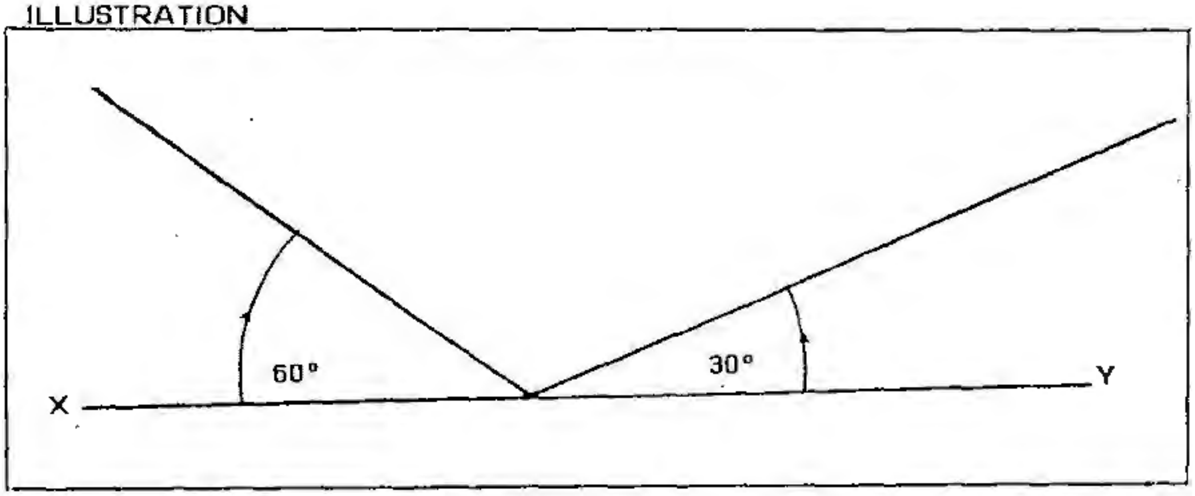
Eighty per cent of the pupils who were interviewed in the study could not make the correct illustration of a three-dimensional representation on a two-dimensional surface.

5.3.3.1 Pupils' problems : Three-dimensional representation

Pupils were provided with answer sheets on which clear guidelines to the illustrations were supplied. The answer sheet consisted of the main principle XY-line (base) and two bottom lines of the illustration, lifted from the base line at an angle of thirty degrees and the other side at an angle of sixty degrees.

FIGURE 4

ILLUSTRATION

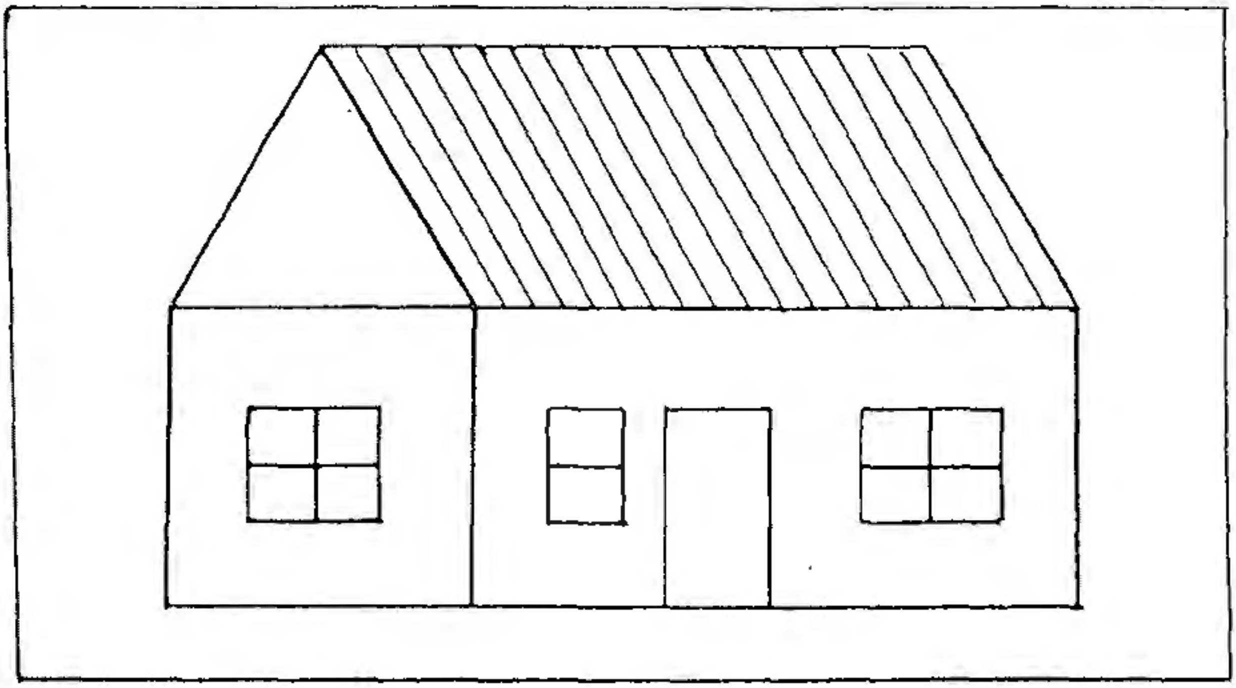


Mistakes in pupils' illustrations in this case were as follows: most pupils could not place the longer side of the figure at the side lifted thirty degrees above the base-line and the shorter side of the figure at the side lifted sixty degrees above the base line (XY). This implies that the above aspect fades from pupils' memories as new knowledge is acquired and accumulated.

5.3.3.1.1 Surface perception of pupils

Most pupils illustrated both sides of the figure as lying flat on the same straight line. They totally ignored the given guidance towards the correct answer.

FIGURE 5

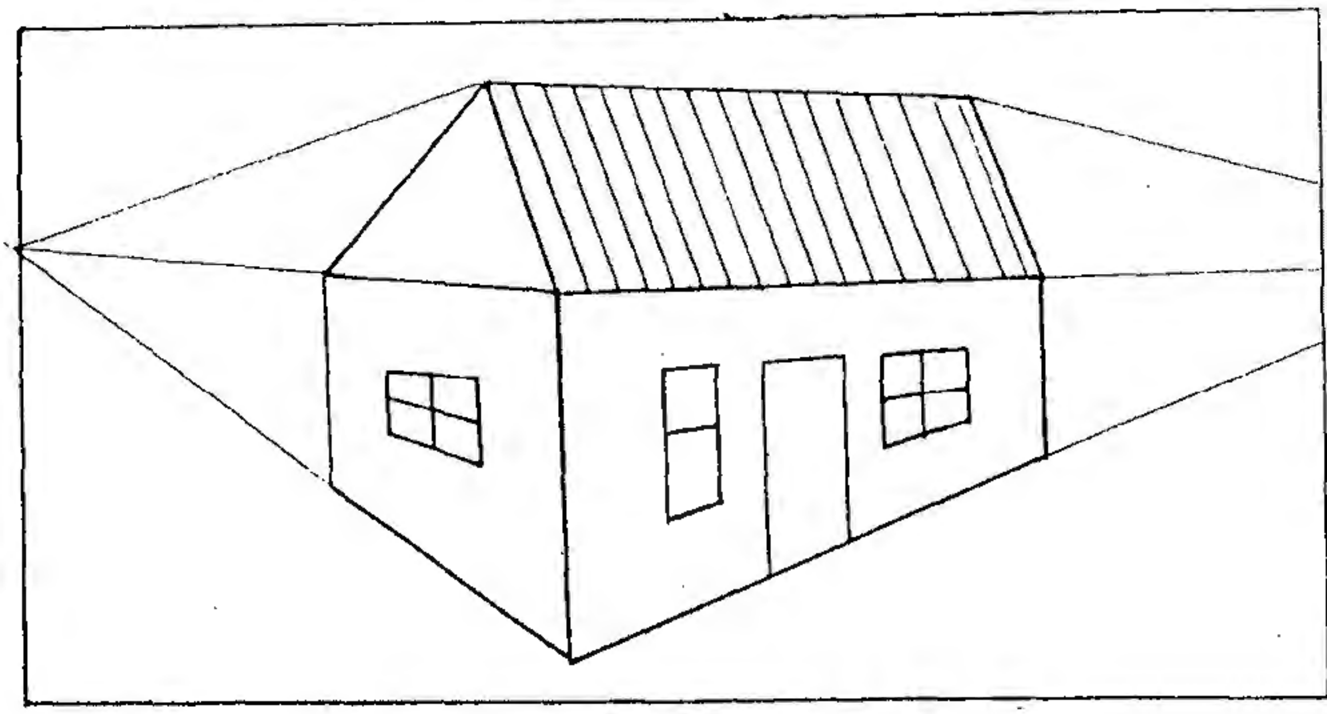


This figure shows that pupils represented what they normally saw and experienced in everyday life. Normally they observe a house with all four sides on the same flat level and this is not theoretically applicable in Technical Drawing.

5.3.3.1.2 Length perception of pupils

Most pupils visualized the middle line, that is, the corner between the angle of sixty and thirty degrees, as the longest and the rest as shorter. In other words, pupils illustrated the figure from the point of view that the lines would eventually vanish (vanishing point of view).

FIGURE 6

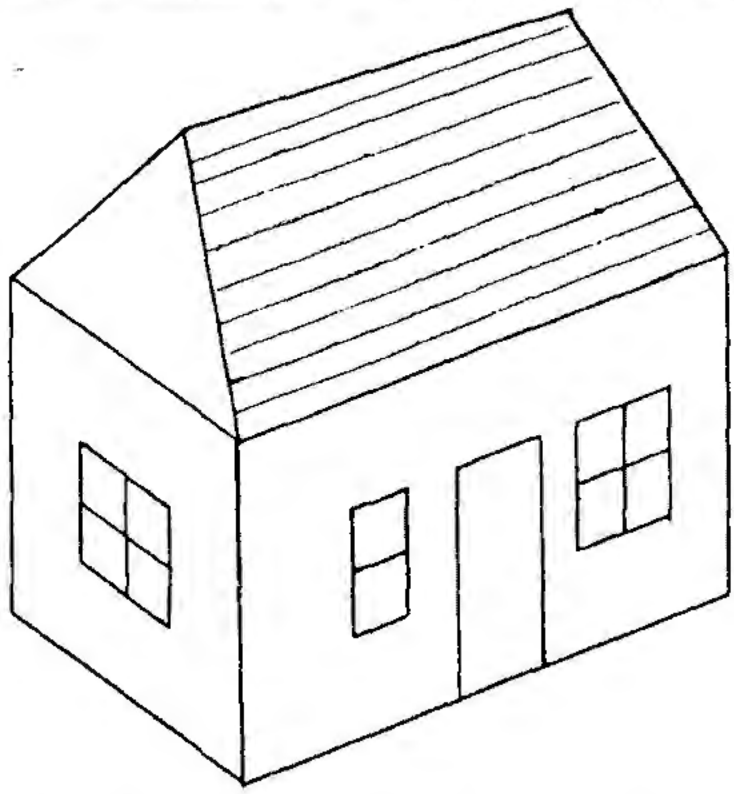


This figure shows that pupils did in fact use the given guidance from Figure 4. They managed to place the shorter side at an angle of sixty degrees above the base-line and the longer side at thirty degrees above the base-line. The only problem was that, due to what they normally observed in everyday life, they perceived that, if two objects were equal in size, the one which was placed nearer to the viewer appeared to be longer or bigger in size than the one which was a longer distance away from the viewer. as a result they illustrated their figures according to this perception.

5.3.3.1.3 Correct illustration (Three-dimensional representation)

The figure below is the correct illustration of a three-dimensional representation on a two-dimensional surface.

FIGURE 7



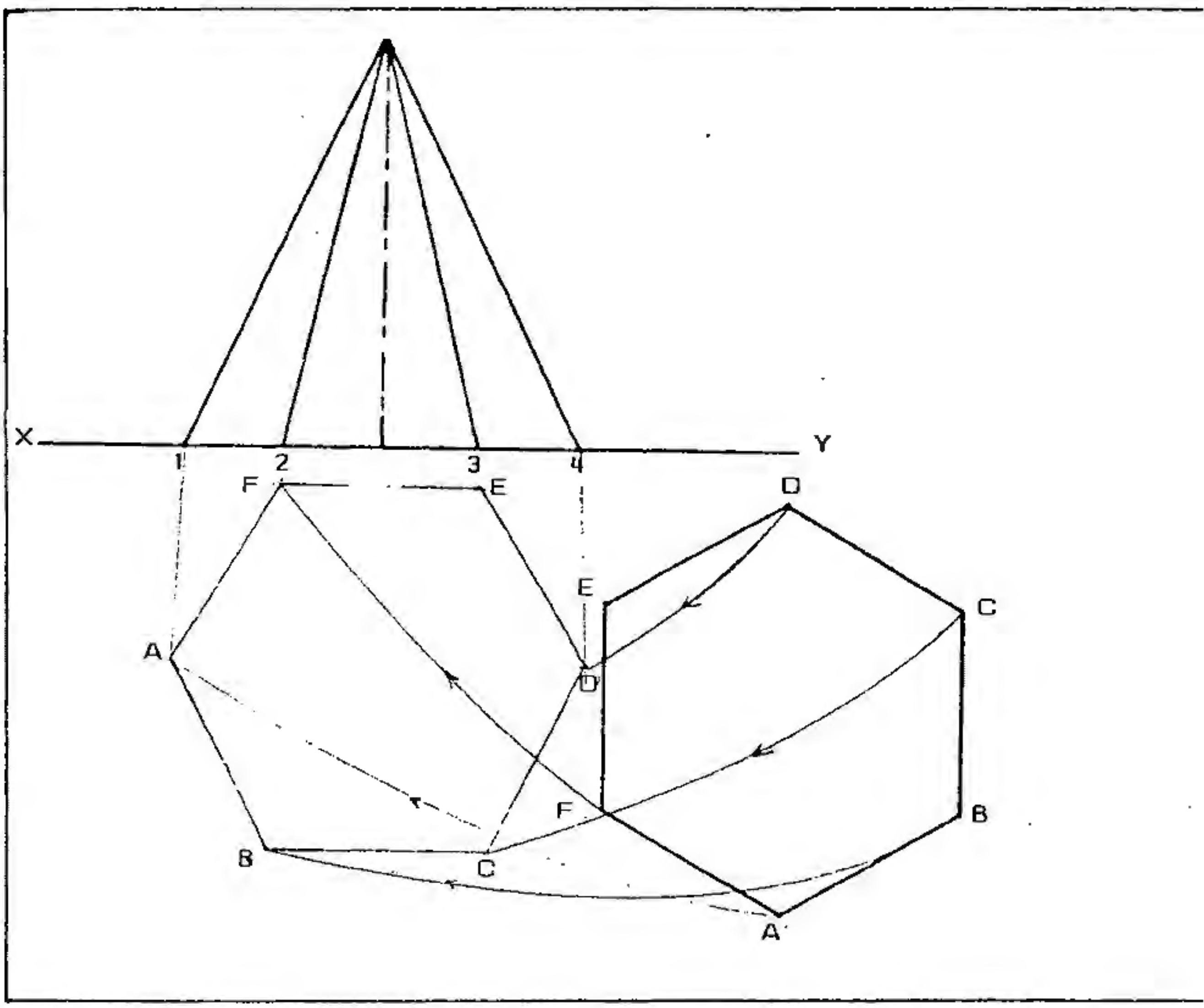
5.3.3.2 Abstraction and perception

Sixty per cent of the interviewed pupils could not match the lines numbered 1 to 4 on the front view of the hexagonally based pyramid with the appropriate top view corners numbered a to f (see Figure 8). Their answers reveal that they do not have the ability to reverse abstraction and perception; for example, they were unable to reverse abstractly the top view from its present position, to its original position below the base-line directly under the front view.

Alternatively, they could have produced construction lines to join the top view with the front view. Through construction lines, successive stages which led to the present position of the top view can be traced.

The figure below represents the correct illustration of the matching problem [see Appendix B].

FIGURE 8



5.3.3.3 The sectioning of solids

The question concerning the sectioned rectangular pyramid required clear concepts about the sectioning of solids. The problem experienced with this question is that sectioning is only taught in detail in senior classes, e.g. standard eight, nine and ten programmes. Nevertheless, forty per cent of the interviewed pupils managed to get the problem right. Although this question was correctly answered, there is a need to improve the line work of pupils so that a clear distinction can be made between lines that indicate construction, borders, the centre and hidden details.

ILLUSTRATIONS

Construction line

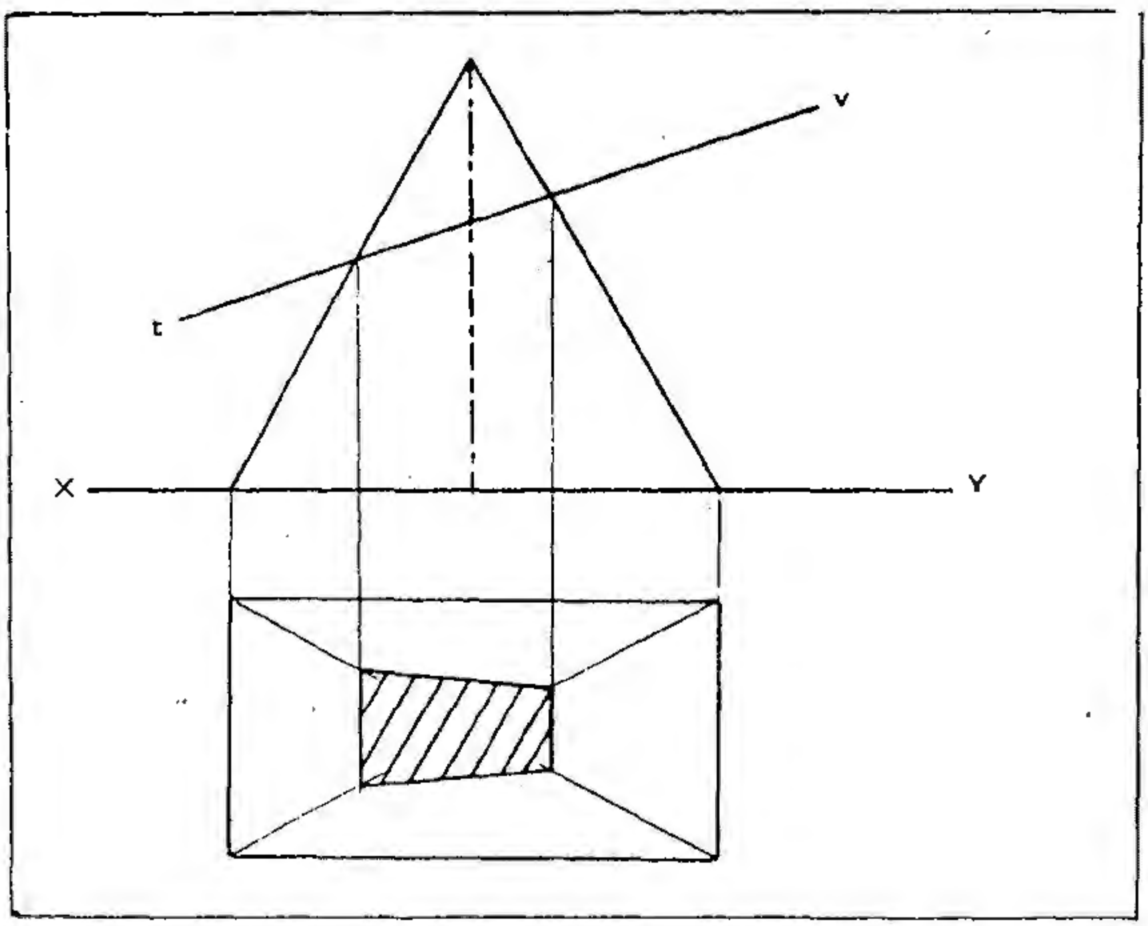
Border or outline

Hidden details

Centre line

This figure below represents the correct illustration of a problem requiring the sectioning of solids

FIGURE 9



5.3.4 Generalization of pupils' problem

Although it is difficult to draw a set of neat frameworks which classify each mistake of the pupils, an attempt is nevertheless made to group pupils' mistakes in the learning of Technical Drawing. Even if this attempt is executed, the key fact is that all problems in the teaching and learning of Technical drawing result from poor development of concepts which is caused by the lack of concept teaching techniques and a number of related aspects.

5.3.4.1 Perception and dimensioning

Pupils view objects as lying on a flat surface. This aspect is deduced from a three-dimensional representation on a two-dimensional surface, where pupils neglected the model answer and represented both sides flat or horizontally (see Figure 5).

Dimensions appear to be of less importance in the representation of most illustrations. This aspect is deduced from the various sizes of the same figure as it appeared on different pupils' answer sheets. Different sizes of the same figure show that pupils disregarded the given dimensions and made illustrations without measurements.

This appears to confirm Groenewald's idea which has already been discussed in Chapter 1, paragraph 1.4, concerning cultural groups and the milieu in which a child is brought up.

Empirical evidence shows that Black pupils are brought up in a milieu where objects are differentiated between as "big" or "small", others are located as "near" or "far" without attention being paid to the actual dimensions or distances. It is therefore not strange to have pupils who have very little understanding of the importance of dimensions, because they do not view objects in their everyday life in terms of their accurate measurements.

To most pupils the front corner of the house, positioned between two sides, one lifted at an angle of thirty degrees and the other one at an angle of sixty degrees, is the longest and the rest are shorter (see Figure 6).

All pupils interviewed have a problem with the forming of concepts. Besides the factors mentioned in Chapter 1, paragraph 1.4, this problem might be rooted in the way they are taught most of their subjects in the lower classes, where rote-learning is strongly emphasized at the expense of learning with insight. This aspect covers all activities of examinations, tests and classwork, where pupils are required to memorise certain facts in order to reproduce them when required.

5.3.4.2 Background problem

There are also other factors besides inadequate teaching techniques applied in the teaching of Blacks in Technical Drawing, which result in the forming of poor concepts, namely: poor control of English, poor training of teachers and the environment in which they are brought up being materially impoverished in terms of Western standards. In a normal material environment a pupil would have access to a wide range of objects like, domestic articles, tools, books, magazines, pictures, etc. In addition, the tasks which Black pupils have to perform at home and at school, require no particular intellectual effort. As a result their potential to form concepts is not stimulated until at secondary school level when they start learning subjects like Technical Drawing.

The meagreness of the Black child's material environment and the way he is taught and brought up, have specific implications for the nature of his classroom environment in order for it to promote the formation of clear concepts.

5.3.5 Findings with reference to observation

The observation schedule or checklist was completed by the researcher during ten Technical Drawing lessons and the findings were as follows:

5.3.5.1 Classroom environment

Concerning classroom environment, it was found that eighty per cent of the Technical Drawing localities needed to be improved in order to be conducive to the teaching and learning of Technical Drawing. This situation is influenced by insufficient teaching aids (wall diagrams and models), a fact which is proved by the research results referred to in Chapter 3, paragraph 2. It is therefore not strange to find the Technical Drawing locality as poorly arranged and equipped in terms of the demands and the nature of Technical Drawing.

The Technical Drawing locality has a major role to play in the forming of concepts through the observation of relations. This implies that pupils should be confronted with the concrete realities of drawing directly upon their entrance into the classroom. This presupposes the availability of suitable wall diagrams of boilers, hydro-electric installations, internal combustion engines, involutes and cycloidal curves, etc.

A lack of the above-mentioned visual aids, limits the success of teachers' demonstrations in the presentation of their lessons. This encourages teachers to depend on explanations through the medium of the second language, which in itself is a problem to Black pupils. As a result, pupils develop poor concepts about what is being presented.

5.3.5.2 Classroom activity

One of the key problems in the teaching of Technical Drawing appears to be that teachers spend too much time explaining new concepts. Most of the observed teachers spend more than half the period explaining new concepts. The fact that most teachers were not in favour of using the mother-tongue to drive home concepts, was confirmed during observation of lesson presentations. This practice makes it difficult for teachers to attach new concepts to the existing concepts of the pupils, because pupils experience problems in expressing their own concepts to the teachers through the medium of a foreign language.

When Technical Drawing teachers experience and fail to practise drawing constantly, it affects their illustrations on the chalkboard in the following ways:

Those who are accurate and neat in their illustrations, spend half of the period facing the board and by the time they have finished, more important aspects of the lesson have long since escaped the pupils' minds. Those who appear to be fast when making illustrations, fail to make an accurate representation of all the characteristics which a teacher would like to see incorporated in the pupils' drawings.

Pupil involvement, as observed in the teaching of sixty per cent of the teachers, appears to be a situation where one or two pupils are given a chance to make an illustration on the chalkboard, while the rest of the class just observe. Therefore pupils need to receive more individual attention and they should be actively involved to a much larger extent.

Sixty per cent of the interviewed teachers rejected the idea that pupils should be free to help one another in solving classwork problems. However, seventy per cent of the pupils felt that they were given freedom to ask help from their fellow-pupils in solving classwork problems. Through observation, it was found that the pupils were allowed a certain measure of free interaction in solving classwork problems. However, in relation to the nature and demands of Technical Drawing, the situation needs to be improved.

5.3.6 Findings related to the heads of technical departments' questionnaire

Five questionnaires were administered during interviews with five different heads of technical departments and the findings were as follows:

5.3.6.1 Background and subject knowledge

It was found that sixty per cent of the heads of technical departments were Whites. This implies that they have different social and educational experiences, a different cultural background and above all conceptual frames of difference which differ from those of Black teachers and pupils.

Eight per cent of them had never taught in Black schools and were at that point in time not teaching Technical Drawing, but were only responsible for its management and control. Eighty per cent were not teachers by profession, but were qualified technicians and skilled tradesmen, which means that they did not have any knowledge or experience of the didactical approach to the teaching of Technical Drawing. Nevertheless, they possessed an adequate knowledge of operating and repairing workshop machines.

Seventy per cent of them responded positively to questions concerning whether they had learned a form of drawing at some stage as a school subject and whether they enjoyed listening to Technical Drawing lessons. What the researcher found surprising was that eighty per cent of them could not mention any aspect which was of great interest to them in Technical Drawing lessons. This implies that these two questions were not honestly answered.

5.3.6.2 Management and control

All heads of technical departments consider Standard Five Mathematics results important for admission of pupils to technical education. However, the Standard Five Mathematics examination paper is not standardized because each primary school sets its own examination paper.

Ninety per cent of the heads of technical departments responded negatively to the question whether the Technical Drawing syllabus was defined with clear guidelines for inexperienced teachers. This is an indication that there is mutual agreement between Technical Drawing teachers and heads of technical departments concerning the problems and shortcomings of the syllabus.

It is further encouraging to find that seventy per cent of the heads of technical departments expressed a willingness to help teachers with the problems related to the teaching of Technical Drawing. The only discouraging factor is that ninety per cent of the heads of technical departments, being aware of the problems which teachers and pupils experience in the teaching and the learning of Technical drawing, had not done anything to motivate pupils in the learning of the subject. It is therefore not strange that forty per cent of the pupils had already developed a negative attitude towards the learning of Technical Drawing as a school subject.

Ninety per cent of the heads of technical departments did not consider availability of visual aids (wall diagrams and models) to be a problem and believed their schools to be fully equipped. It-was interesting to note the conflicting views of teachers who were teaching the subject and authorities who were managing and controlling the teaching of the subject.

The possible implication of this discrepancy is that teaching aids are available, but teachers do not know how to use them, or heads of technical departments do not have an idea about the quality and quantity of teaching aids required in the teaching and learning of Technical Drawing. There is a strong probability that the heads of technical departments are just defending the inadequate supply of ready-made teaching aids from a specific source.

Heads of technical departments were generally very sensitive about questions which referred to their qualifications and questions regarding the shortage of text books and visual aids which are supposed to be supplied by the Department of Education and Training. Their evaluation of all the questionnaires during pilot study was very neutral and non-committal and did not reveal any knowledge or insight into issues probed by the study. These reactions showed an implicit avoidance of the issues being investigated by this study.

5.4 CONCLUSION

Critical evaluation in the teaching and learning of Technical Drawing in Black schools is aimed at revealing methods of tuition presently being applied. This study highlights the following aspects as the crux of all the findings, based on the results of the questionnaires that were administered to different parties and the scheduled observation conducted by the researcher:

Black teachers lack practical experience in the teaching of technical subjects as a whole.

Pupils understand new concepts better in Technical Drawing when visual aids are used. However, there is a shortage of visual aids (wall diagrams and models) in Black schools.

Black pupils experience problems with English which is used as the medium of instruction.

Classroom interaction in the teaching of Technical Drawing should take the nature of the subject into consideration.

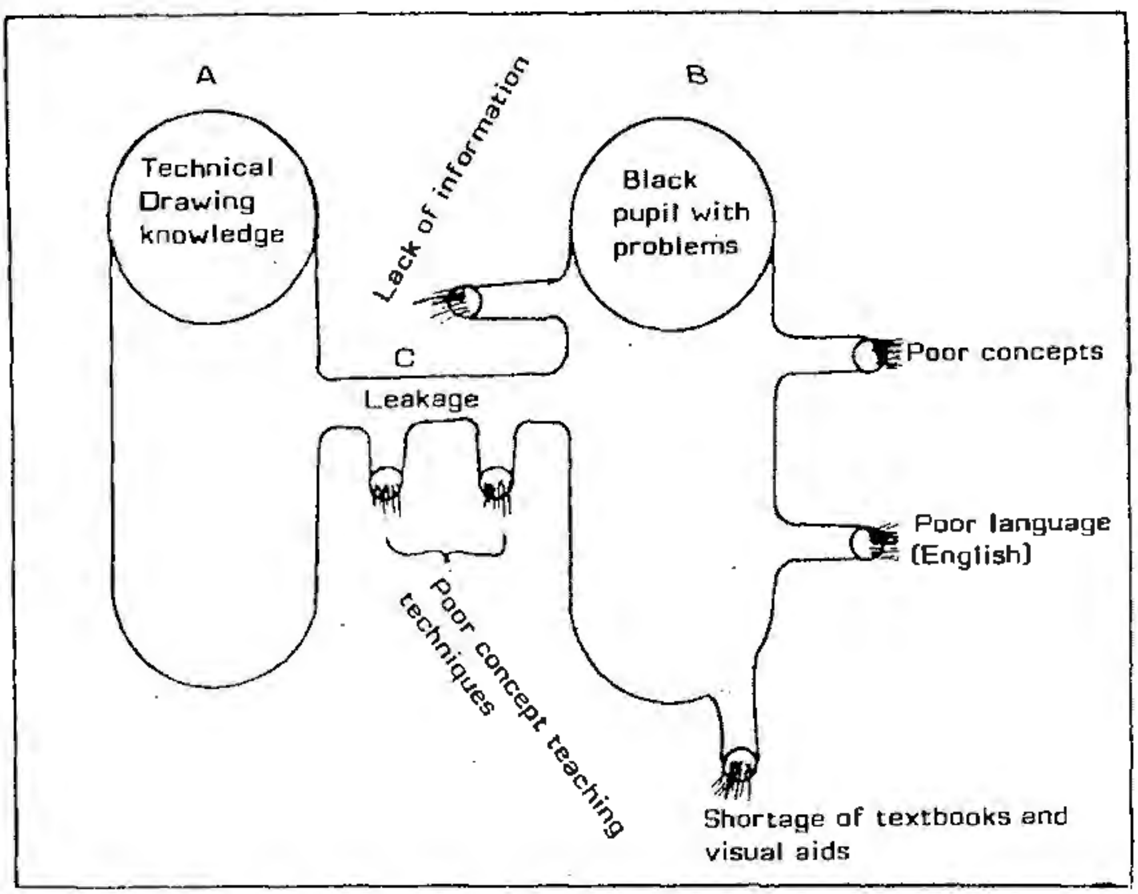
Pupils are not well-motivated in the learning of Technical Drawing.

Heads of technical departments need appropriate qualifications; well-grounded knowledge of the subject and knowledge of the cultural background of pupils under their control.

Above all, pupils lack clear concepts in the learning of Technical Drawing, because Technical Drawing teachers fail to apply concept teaching techniques.

The conclusion concerning problems in the teaching and learning of Technical Drawing in Black schools, can be interpreted and illustrated by the researcher of this study as follows:

FIGURE 10



In figure 10, A, represents the subject, Technical Drawing with skills, concepts, etc., to be transmitted to B, the pupil, through channel C, Technical Drawing teacher.

The teacher represented by channel C, has to cope with problems such as a poorly defined syllabus, and a shortage of visual aids and textbooks. Lack of concept teaching techniques and his personal lack of experience in the teaching of Technical Drawing add to existing problems. As a result, there are knowledge and concept "leakages" between the teacher and the subject.

Figure B represents the pupil, who wants to realize his potential through adequate Technical Drawing skills and clear concepts. The pupil cannot form clear concepts in Technical Drawing, because of the following:

Poor control of the language which is used as a medium of instruction.

A materially impoverished environment in which he has been brought up.

Poor motivation which he received from the teachers and the heads of technical departments.

Lack of visual aids to help them to understand certain abstract concepts and other related problems.

As a result of all the above-mentioned facts there is also a "leakage" on the pupils' side. The above serves to confirm the hypothesis made in Chapter 1, paragraph 1.1 .3 .

5.5 SUMMARY

This chapter has outlined the research findings and conclusions concerning the critical evaluation in the teaching and learning of Technical Drawing in Black schools. In the next chapter recommendations concerning the research findings are made.

CHAPTER 6

RECOMMENDATIONS BASED ON THE RESULTS OF THE RESEARCH

6.1 INTRODUCTION

Issues arising from the practical study and their implications have been fully discussed in chapter five. In this section, major areas of concern from the findings are highlighted and suitable recommendations are made to combat the problems raised.

Recommendations made are derived mainly from the findings of this research project.

6.2 OVERVIEW OF THE CONCLUSIONS

Wherever posts are advertised by the Department of Education and Training, Department of Education and Culture, or by the private sector, previous experience is required. This implies that experience is regarded as extremely important in all occupations. Therefore experience in the teaching of Technical Drawing is also important and the value of experience and good training in the teaching of this subject cannot be over-emphasized. In Chapter 5 paragraph 3.1 of this study, the role of experience and good training in the teaching of Technical Drawing has been discussed.

In this study, seventy per cent of the interviewed teachers had less than five years' teaching experience. This implies that most of the Black Technical Drawing teachers lack practical experience concerning appropriate teaching techniques which can be applied to develop or promote the forming of clear concepts.

In Chapter I paragraph 1.4, Duminy (1976:39) discusses the value of perception in teaching and learning. In the light of this information about the importance of involving all the senses in teaching and learning, it is not strange that seventy per cent of the interviewed pupils said that they understood new concepts better when teaching aids (wall diagrams and models) were used. However, eighty per cent of the interviewed teachers evaluated their schools as being poorly equipped with textbooks and visual aids, which are required to promote the forming of clear concepts when learning Technical Drawing.

In the Department of Education and Training Blacks are taught through the medium of their mother-tongue during the initial stages of their school career. They are only introduced to a second language as medium of instruction after completing the first four years of their school career. According to research findings in this study, eighty per cent of the interviewed teachers said that pupils experienced problems to understand and communicate in English, as the medium of instruction in Black schools.

In Chapter 1 paragraph 1.4.2 Engelbrecht discusses the role of language in learning. From the information gathered, it is not strange that seventy per cent of the interviewed pupils said that it was difficult for them to understand most of the concepts in Technical Drawing. The main reason for this fact is the pupils' inability to communicate in English, which hampers their insight into and mastering of any subject which is taught through the medium of English. This aspect of the language problem has certain implications concerning interaction in the Technical Drawing classroom.

In Part B of this study, Black pupils were practically involved in the solving of certain Technical Drawing problems, like a three-dimensional representation, sectioning of solids and a first angle orthographic projection. Through analysis of their answer sheets, it was found that they lacked analytical and depth perception. According to Swart (1988:178) Chapter 1 paragraph 1.4, this is caused by lack of concept teaching techniques among Black teachers. This is why eighty per cent of the interviewed pupils said that they seldom finished Technical Drawing problems.
Lack of concept-forming unquestionably slows down the speed of pupils in solving Technical Drawing problems.

As the head of a department of African languages, the researcher himself experienced in practice that knowledge of the subject and teaching methods related to it, as well as knowledge of the cultural background of pupils under his control, could inspire someone in that position to guide and motivate teachers and pupils. In this study, research findings indicate that sixty per cent of the heads of technical departments were Whites. Ninety per cent of them were not professionally trained teachers, but technicians and skilled tradesmen. In the discussion they held with the researcher, it was found that they did not possess any knowledge of the cultural background of pupils whom they were leading to adulthood. They also did not possess knowledge of Technical Drawing, but possessed a sound knowledge of Machine Drawing.

6.3 RECOMMENDATIONS CONCERNING EXPERIENCE

Concerning the actual teaching of Technical Drawing, it was observed that there were two groups of Technical Drawing teachers, namely those who were fast and those who were slow in completing their illustrations on the chalkboard.

Recommendations are made for each of the above-mentioned groups concerning the most suitable method of making illustrations.

Teachers who are fast in completing their illustrations, but who fail to produce an accurate representation, need to keep in mind that illustrations on the chalkboard clearly manifest their attitude toward Technical Drawing.

It is therefore recommended that Technical Drawing teachers should acquaint themselves with the use of the chalkboard, not only as a medium of expression, but especially as a medium of creating an accurate representation of all those features they would like to see incorporated in the pupils' drawings. Every teacher should remember that using the chalkboard to the best advantage is a skill which can, through sustained and dedicated practice, be acquired by any teacher. It serves to record thoughts as they are developed during a lesson. Therefore Technical Drawing teachers should under no circumstances allow their illustrations on the chalkboard to undermine their attempts to emphasize neatness and accuracy.

It is recommended that those teachers who make accurate and neat illustrations, but spend half the period facing the chalkboard, should prepare their lessons thoroughly beforehand. This can only be achieved by making illustrations on transparencies, so that an overhead projector can be used. It is important to know that well-prepared transparencies, if carefully filed by the teacher, can be used repeatedly over a period of five years.

At schools where there is neither overhead projector nor electricity, illustrations should be made neatly and accurately on charts. The following two methods are recommended for making of transparencies and wall charts:

The teacher can use a number of transparencies or small charts, each containing a specific step or part of the drawing or illustration. He can then combine them in stages and explain each step perfectly until the whole illustration is completed.

The teacher can make a complete illustration on the transparency or wall chart. In this case, it is very important that he should never forget to demonstrate all the necessary successive stages which lead to the completed illustration on the chalkboard.

6.4 PROBLEMS CONCERNING INTERPRETATION OF THE SYLLABUS

There is a need for the Technical Drawing specialist to give guidance to heads of technical departments and subject teachers with regard to the interpretation of the syllabus. The following recommendations should prove useful to such a specialist:

He should discuss and explain the exposition of the syllabus contents to Technical Drawing teachers.

He should conduct regular in-service training courses and demonstration lessons for all Technical Drawing teachers, wherein concept teaching techniques are demonstrated.

He should ensure that all comprehensive high schools maintain an equal standard and degree of progress by setting tests and examinations for all Technical Drawing teachers.

He should facilitate communication between teachers of different schools, through the establishment of a Technical Drawing committee which will enable teachers to help one another in solving problems related to the teaching of

Technical Drawing. Such a committee can be involved and consulted when educational authorities draw up a new syllabus or improve the existing one. Such involvement of persons who are practically dealing with teaching and learning, can eliminate problems with the interpretation of the syllabus as shown in Part A of this study.

6.5 RECOMMENDATIONS CONCERNING THE SHORTAGE OF TEXTBOOKS AND TEACHING AIDS

This aspect of teaching requires hard work, innovation, sacrifices and intelligence on the part of the teacher. It is very important as a Technical Drawing teacher to know that teaching aids do not only refer to ready-made models and charts, supplied by a firm or the Department of Education. In this study, research findings indicate that sixty per cent of the interviewed Technical Drawing teachers did not view themselves as being responsible for providing their pupils with teaching aids. The implication here is that sixty per cent of Technical Drawing teachers misunderstand a key aspect concerning teaching aids (wall diagrams and models).

6.5.1 How common objects can be used as visual aids

In Technical Drawing, every object which one comes across in everyday life can be used as a very valuable teaching aid. However, it should be mentioned that this can only happen if the teacher is innovative and intelligent enough to sense its possibilities. How these objects should be used, depends on what the subject matter requires from pupils.

A good example of the above-mentioned fact is the principle of orthographic projection in Technical Drawing which requires that pupils should be able to visualize images of elevations projected on the three supporting planes (see Figure number one or three in Chapter five). This exercise in using their imagination often requires a high standard of abstraction from pupils, and a more practical method which can be applied without the use of any ready-made or expensive teaching aids is the following:

The teacher should deposit an object with a regular shape (e.g. a brick) in a box from which three sides have been removed. Subsequently, the teacher must show

how the object can be viewed orthographically from three different directions and then be projected on the sides of the box behind the object to show the three views in perfect line with one another when the sides are hinged back to form one level (Appendix E).

In this study, research findings indicate that eighty per cent of the interviewed Technical Drawing teachers thought it was impossible for them to acquire teaching aids. In the previous paragraphs it has also been mentioned that sixty per cent of the interviewed Technical Drawing teachers did not view themselves as responsible for providing their pupils with teaching aids. These two findings imply that Technical Drawing teachers do not want to accept full responsibility for their subject. It is therefore recommended that Technical Drawing teachers should do so and be prepared to sacrifice time for the making of teaching aids and to spend money on buying them when necessary, because no school has sufficient teaching aids.

6.5.2 How to substitute textbooks

The best method to overcome a shortage of text books at school is to apply a system where pupils are provided with neatly typed notes containing all the important diagrams and the methods of constructing them. These methods should be clearly outlined. Notes which the pupils keep in a file can easily replace textbooks - in fact they might even serve a better purpose than textbooks, because they only contain important aspects relevant to the syllabus. Pupils can refer to them from time to time when they find it necessary (Appendix F).

In this study, research findings indicate that seventy per cent of the interviewed pupils seldom finished Technical Drawing problems during the allocated periods. It is therefore recommended that, concerning classwork, tests and examinations, pupils should be provided with answer sheets, containing instructions, diagrams with all the necessary dimensions, border lines and spaces where pupils can fill in their names and classes. This will save time for those pupils who do not complete their problems during the allocated periods (Appendix G).

With regard to senior classes, especially Standards Eight, Nine and Ten, it is recommended that pupils should be provided with question papers from previous examinations and solutions to different problems. This will enable pupils to learn different techniques which can be applied in the solving of Technical Drawing problems (Appendix H).

6.6 RECOMMENDATIONS CONCERNING THE MEDIUM OF INSTRUCTION

In this study, research findings indicate that eighty per cent of the interviewed Technical Drawing teachers evaluated their pupils' ability to communicate in English as generally poor. This implies that Black pupils experience problems with English as the medium of instruction. However, this aspect does not permit the researcher to suggest without further ado that Blacks should be taught through the medium of their mother-tongue. There are two important problems which prohibit such a recommendation.

6.6.1 Introduction of Technical Drawing to the school curriculum

The first problem in paragraph 6.1 arises from the purpose of introducing Technical Drawing into the curriculum as a school subject.

Technical Drawing is the "language" of the engineering and building industries, and it has a vocabulary and terminology of its own, apart from the graphic representation. Introducing Technical Drawing into the school curriculum should therefore be understood as an attempt to teach the pupil the "language" of an integral part of a course which he might follow at a university, technikon or industrial training centre to prepare himself for his future career.

The instruction of Technical Drawing at school is primarily an educational matter which is aimed at the child's attainment of adulthood so that he can fulfil his proper role in society.

Technical Drawing, among other subjects, manifests itself through graphical design, graphical communication and visualization. Knowledge of and competence in Technical Drawing manifest themselves in the ability to interpret certain information from the drawing and an ability to represent ideas graphically.

It can therefore be concluded that Technical Drawing has a major role to play in the lives of people, because it leads to a balanced personality. As a result those who have chosen to be Technical Drawing teachers, must teach it to the best of their ability.

6.6.2 **Black language as a medium of instruction**

The second problem mentioned in paragraph 6.1 arises from the question whether a Black language has all the necessary technical terminology to express Technical Drawing concepts clearly and economically.

In the Republic of South Africa, although multi-lingual, commercial and industrial languages are official languages. This implies that the skilled manpower required in the industrial sector cannot be hampered by weak communication in the official language. As a result those who have acquired their education through the medium of an official language, will enjoy preference above those who have acquired their education through the medium of a Black language, thus creating unequal job opportunities in the labour market.

In Chapter Two of this study, paragraph 2.5.5, the researcher referred to Terblanche's sketch of the racial composition of the technological component in twenty-two companies, which shows that there is a great shortage of Black artisans, engineers and technologists. In order to meet such a need, it is recommended that instruction through the medium of a Black language should be totally discouraged. The main reason is that instruction through the medium of a Black language, will unquestionably produce artisans and engineers who cannot communicate efficiently and fluently with their fellow-engineers of other racial groups, thus hampering the process of providing sufficient manpower, so essential for the economic growth of the country.

The mother-tongue of Black people does not have the necessary technical vocabulary in order for it to be used as the medium of instruction throughout the school career of pupils, because it does not keep pace with modern technological developments. It would further be an expensive system to implement, because of a lack of textbooks in Black languages. Translating existing textbooks into different Black languages has certain technical pitfalls, because concepts are better expressed in the subject's original language. Most secondary schools, if not all, in urban Black residential areas, cater for more than one ethnic language. In Chapter Three paragraph 7.2" on the pupils' background, the ethnic languages of pupils admitted to technical education at the local comprehensive high schools have been mentioned. This implies that, if a Black language is to be used as a medium of instruction, provision should be made for all ethnic languages in the same school. It is also important to mention that there will be a shortage of teachers, because although most Black teachers can speak more than three ethnic languages, they cannot use them as a medium of instruction. Using a specific language as a medium of instruction, requires mastering its syntax and semantics.

It is therefore not recommended that any Black language should be used as a medium of instruction. It can, however, be used to explain certain difficult concepts in Technical Drawing, if possible. In order to improve second language competence among Black pupils, it is recommended that they should be exposed to it when entering primary school. The primary school environment should not be materially impoverished in terms of Western standards. Whenever they are exposed to the second language at this stage, the whole learning process should be based on visual material which they can actually observe in the classroom, for example, wall charts, pictures, etc. This will facilitate the acquisition of the second language. As a result new vocabulary will not be memorized as linguistic entities.

It is further recommended that special attention should be paid to the teaching and learning of English as a subject in order to improve communication where it is used as the medium of instruction across the curriculum.

6.7 RECOMMENDATIONS CONCERNING DEVELOPMENT OF CLEAR CONCEPTS

Pupils should be exposed to intellectual challenges right from primary school level. This can easily be achieved if teaching techniques which promote the development of concepts rather than rote-learning are applied. This includes methods of setting assignments, tests and examinations. Pupils should be engaged in all activities which stimulate thinking. This implies that instructions given to pupils must be well-planned beforehand. The classroom environment must arouse pupils' curiosity, because visual perception in particular, develops in accordance with that which is usually accessible in the world which surrounds the child.

Concerning free-hand drawings, in the junior classes, for example Standard Six, it is recommended that before any graphic representation of objects can be made, a clear mental picture should have been formed. The clearness of this mental image is in turn determined by the intensity of the observation. It is therefore necessary to concentrate on visual presentation in the first instance.

In this study, research findings show that seventy per cent of the observed teachers did not satisfactorily involve pupils in the learning of Technical Drawing and this aspect needs to be improved. It is therefore recommended that special emphasis should be placed on paying individual attention to each pupil, because it ensures that every task given to pupils is carried out satisfactorily.

This implies that in each class, the teacher of Technical Drawing should circulate among his pupils and examine every presentation individually. By means of questions, the teacher should attempt to trace the reasons for incorrect work and the pupil's personal difficulties in the subject should be discussed with him. If the teacher notices that a particular mistake is made by the majority of pupils, the chalkboard should be used to bring the mistake to the notice of the whole class simultaneously. The general mistake may serve as a topic for discussion and through questions the teacher must stimulate pupils to voice their opinions. This implies that the Technical Drawing teacher needs to be patient because his personality plays a cardinal role in making pupils realise their potential and or problems in Technical Drawing.

6.7.1 Pupil involvement

In this study, research findings show that sixty per cent of the interviewed teachers, were not in favour of a situation where pupils assisted one another in solving classwork problems. It is therefore highly recommended that intelligent pupils should be encouraged to help the weaker ones. By so doing, they will attach their concepts to the concepts of their fellow-pupils. It is very important that Technical Drawing teachers should always keep in mind that inordinate strictness will not result in pupils' developing the desired reasoning ability. Some times it may result in lack of interest in and an aversion to the subject. It is therefore recommended that the Technical Drawing teacher should have the following characteristics:

Emotional stability which will limit striking fear into pupils.

The ability to present his lesson in a very logical and understandable manner.

He must be an example of accuracy and neatness.

The ability to change and vary his teaching methods and to acquaint himself with concept-teaching techniques.

The ability to communicate on an informal and social level with his pupils.

The above-mentioned characteristics, will enable pupils to get a chance to formulate and motivate their own point of perception. Thus an attempt by the teacher to guide his pupils' independent interpretation of the Technical Drawing illustrations will have been made.

In this study, research findings show that seventy per cent of the observed teachers' method of attaching their concepts as teachers to pupils' concepts was inadequate. It is therefore recommended that the presentation of new concepts be provided with a concrete-realistic example as far as possible so that learning does not remain purely abstract. For example, the concept of cycloidal curves in Technical Drawing can best be understood, if reference is made to the shape of the rainbow. This makes learning more effective and clear concepts will be formed, because many sense-organs are simultaneously employed.

6.8 RECOMMENDATIONS CONCERNING MOTIVATION

The role of motivation is discussed in Chapter 1 paragraph 1.4.1. In the light of the information provided, it is recommended that new concepts in Technical Drawing should be presented in such a way that interest in them is kept up and reinforced.

In this study, research findings indicate that ninety per cent of the interviewed heads of technical departments, did nothing to help teachers to motivate pupils in the learning of Technical Drawing. It is therefore recommended that in order that teachers should gain the co-operation of pupils, they should continually keep in mind that pupils will be engaged in some form of training for an industrial career. As a result, the best method for gaining their co-operation or retaining their interest, without which no instruction can be effective, is to constantly link work done in the Technical Drawing class to appropriate examples of incidents, experiences and applications from industry as well as their own life-world. It is important that the teacher of Technical Drawing should continually impress upon the pupils the part played by drawing in the manufacturing industry. Thus the realization will dawn upon them that the drawing they are practising enjoys full acknowledgement as one of the links in the provision of vital necessities to the community. An example of this, is the first and third angle orthographic projections or details drawing of the diagrams on Appendix I which will motivate pupils who are particularly interested in following industrial careers.

It is further recommended that pupils should be made to realise that the diligent, conscientious and sustained cultivation of the various techniques of Technical Drawing is not necessarily of great use from a practical point of view, but that it results in developing a disposition and qualities of character which are conducive to a balanced personality.

In this study, research findings show that seventy per cent of the Technical Drawing localities visited needed some improvement in order to be conducive to the teaching and learning of Technical Drawing. It is therefore recommended that atmosphere in the classroom should be created by a discerning display of wall diagrams and models in a drawing room. Such a display is an attractive source of information and should introduce pupils to excellent drawings of a high standard. It is further very important to mention that the Technical Drawing locality is the motivating or demotivating factor in the teaching and learning of the subject.

6.9 RECOMMENDATIONS CONCERNING ADMISSION OF PUPILS TO TECHNICAL EDUCATION

In this study, eighty per cent of the interviewed heads of technical departments considered Standard Five Mathematics results as important for admission of pupils to technical education. As a result, seventy per cent of the pupils, admitted to technical education in 1989, scored more than sixty per cent in their Standard Five Mathematics examinations. The average Standard Five Mathematics mark of pupils admitted to technical education in 1989 was 64,8.

It is recommended that this criterion should be used for admission, even if the Standard Five examinations is not standardized because each primary school sets its own examination.

However, there is a need for a Psychometric Test which should be used as an admission criterion. The reason for this, is that there is a probability that Mathematics and Physical Science results alone, do not provide a complete picture of a child's conceptual frame of reference.

It is further recommended that the comprehensive school curriculum should be broad, in order to accommodate those who are not good in Mathematics. Unless the comprehensive school curriculum is broadened, the "best jobs" will go to those few with proven ability and merit, thus reinforcing the disadvantages of those who were brought up in a materially impoverished environment and creating unequal opportunities for individual advancement in society.

6.10 RECOMMENDATIONS CONCERNING HEADS OF TECHNICAL DEPARTMENTS

In this study, research findings show that eighty per cent of the interviewed heads of technical departments were not necessarily professional teachers, but had qualified as technicians or were skilled tradesmen with industrial experience. In this regard, it is important to mention that no head of a technical department can hope to do justice to the management, control and guidance of pupils and teachers, without detailed knowledge of the contents and didactical techniques of the subject under his supervision.

Any head of a technical department without detailed knowledge of Technical Drawing will unquestionably experience problems when giving guidance to inexperienced teachers, concerning the setting of tests and examination papers. It is therefore recommended that such heads of technical departments should always ensure that the mark allocation of a given task is in proportion to the skill required, for example in a task counting 30 marks on first angle orthographic projection, the marks should be allocated as follows:

Correct placing or orthographic elevation	6
Accuracy of details	9
Outlines (density and evenness)	3
Hidden lines (regular spacing)	2
Dimensioning	4
Heading and scale	4
Neatness	2
TOTAL	30 MARKS

Such an allocation of marks makes pupils aware of the most important aspects on which they must concentrate in orthographic projection. Marking any drawing without indicating the distribution of marks, serves no practical purpose in the teaching of Technical Drawing. This means that heads of technical departments should pay more attention to the way pupils' answer sheets are marked. In other words, heads of technical departments should not be checking whether work has been done or not, but should also be taking the quality of work done into account.

6.10.1 Knowledge of the cultural background of Black pupils

In this study, sixty per cent of the interviewed heads of technical departments were from other racial groups. The implication of heads of technical departments, teachers and pupils belonging to different cultural groups, has been discussed in Chapter One, paragraph 1.4 and Chapter Three, paragraph 6.4.

It is therefore recommended that those heads of departments who do not possess a thorough knowledge of the cultural background of pupils, should equip themselves with such knowledge, because this aspect forms an essential conceptual frame of reference upon which pupils' new concepts are built. This can be achieved through formal studies or interaction with the group concerned. Without knowledge of the cultural background of pupils, there is no way the head of a technical department can advise inexperienced Technical Drawing teachers how to link certain new concepts to the existing conceptual framework of pupils. This results in the pupils forming poor concepts.

6.11 SUGGESTIONS FOR FURTHER RESEARCH

The forming of concepts is promoted by a number of aspects, namely: teaching techniques, pupils' competence in the second language and the material environment. However, the material environment of Blacks is not a static phenomenon, it is highly influenced by the economic change in the country. Since it appears that most of their problems in learning Technical Drawing are to a large extent influenced by their material environment, they might change due to modern technological developments. It is therefore suggested that the next researcher who might be interested in Black pupils' learning problems, should investigate the role of the material environment in forming of concepts among Black pupils.

6.12 CONCLUDING REMARK

The researcher believes that better concepts can develop and second language proficiency can be attained among Black pupils, if all efforts can be exerted from the first day pupils enter the classroom situation. The above ideals can be achieved if the following aspects are observed:

Good training of teachers to promote teaching of concepts.

Good teaching programmes.

Material environment which challenges the child's thought and stimulates his curiosity.

Special efforts to promote second language proficiency.

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APPENDIX A

PART A : TEACHERS' QUESTIONNAIRE

1. Your qualification in Technical Drawing

   (a) Professional: ....

   (b) Academic: ....

   (c) Age: .... (d) Sex ....

2. Experience in the teaching of Technical Drawing: ....

3. Did your pupils, expecially standard 6 and 7, make any models from clay or polystyrene?

Yes	No

4. Indicate the approximate number of periods in standard 6 you have used for each of the following aspects in drawing.

	7-8 Period	5-6 Period	3-4 Period	1-2 Period	Un= certain
(a) Line work					
(b) Free hand sketching					
(c) Printing					
(d) Scales					

The following questions are marked according to the value that the teacher assigns to each one - 1= lowest; 5 = highest.

	1	2	3	4	5
5. To what extent is the syllabus defined, with clear guidelines					
6. To what extent do you experience problems with the syllabus interpretation					
7. To what extent do you find it difficult to correlate certain concepts in Technical Drawing syllabus with certain natural phenomena in the life of pupils					
8. To what extent is your school equipped with Technical Drawing aids?					
9. To what extent is it possible for you to acquire Technical Drawing models and charts?					
10. To what extent are your pupils acqainted with Technical Drawing terminology?					
11. To what extent does the school have enough text books in Technical Drawing?					

	1	2	3	4	5
12. How is your pupils' English ability during the lesson presentation?					
13. How often do you ask your Technical Drawing pupils to complete drawing classwork at home?					
14. To what extent is there a continuity between the Technical Drawing syllabus of a primary school and that of a secondary school? (That is, standard five syllabus and standard six syllabus)					
15. To what extent is the responsibility of the Technical Drawing teacher to provide models and charts for his pupils?					
16. Do you think that it is important that Technical Drawing teachers should attend an in-service course regularly?					

17. Do you view the use of models and charts in Technical Drawing as

Very important	Important	Less important

18. What value do you attach to a Technical Drawing locality, with drawing charts on the walls and models all over the displaying tables

Very educative	Educative	Less educative

19. Do you value the use of mother tongue to assist pupils in understanding certain concepts in Technical Drawing as

Very important	Important	Less important

20. What value do you attach to accuracy and cleanliness in Technical Drawing?

Very important	Important	Less important

21. Should children help one another to solve classwork problems in Technical Drawing?

Yes	No

22. How do you value lettering in Technical Drawing?

Very important	Important	Less important

23. How much time do you spend in explaining new concepts to pupils?

5 minutes	6-10 minutes	12-19 minutes	20-25 minutes	Uncertain

24. Why do you teach Technical Drawing?

....

....

....

....

APPENDIX B

PART B : PUPILS' QUESTIONNAIRE

1. Present standard: .... Number in class: ....

2. Age: ....

3. Home language:

Zulu	S.-Sotho	Tswana

4. Parents occupation:

Professional	Labourer	Unemployed

5. Number of family members who stays in the same house:

3	4	5	6	7	8	9+

6. Type of house

4 roomed	Big house	Shack

7. Your standard 5 Mathematics marks

8. Do you get problems in Technical Drawing right?

Yes	No	Sometimes

9. Do you always finish Technical Drawing class work before the end of the drawing period?

Yes	No	Sometimes

10. Do you find most of the concepts in Technical Drawing difficult to understand?

Yes	No	Sometimes

11. Does your teacher allow you to ask for help from other pupils during the drawing lesson, when you experience some difficulties with the given classwork?

Yes	No	Sometimes

12. Does your teacher allow you to go and finish the uncompleted class work in drawing at home?

Yes	No	Sometimes

13. Which subjects are you studying at this technical centre? List them:

(a) ....

(b) ....

(c) ....

14. Which of the subjects you have listed do you not like to do?

....

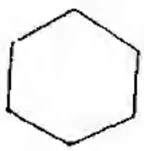
15. When do you understand new concepts in Technical Drawing better?

When models and aids are used	When other pupils help you	Without the use models and aids	When the teacher explains it in detail

16. Do you find it difficult to relate certain Technical Drawing concepts with certain things/objects in your everyday life?

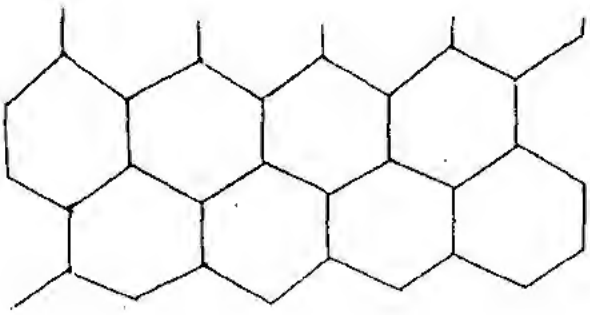
Yes	No

17. What is the technical name of this figure?



Ace	Diamond	Hexagon	Actagon

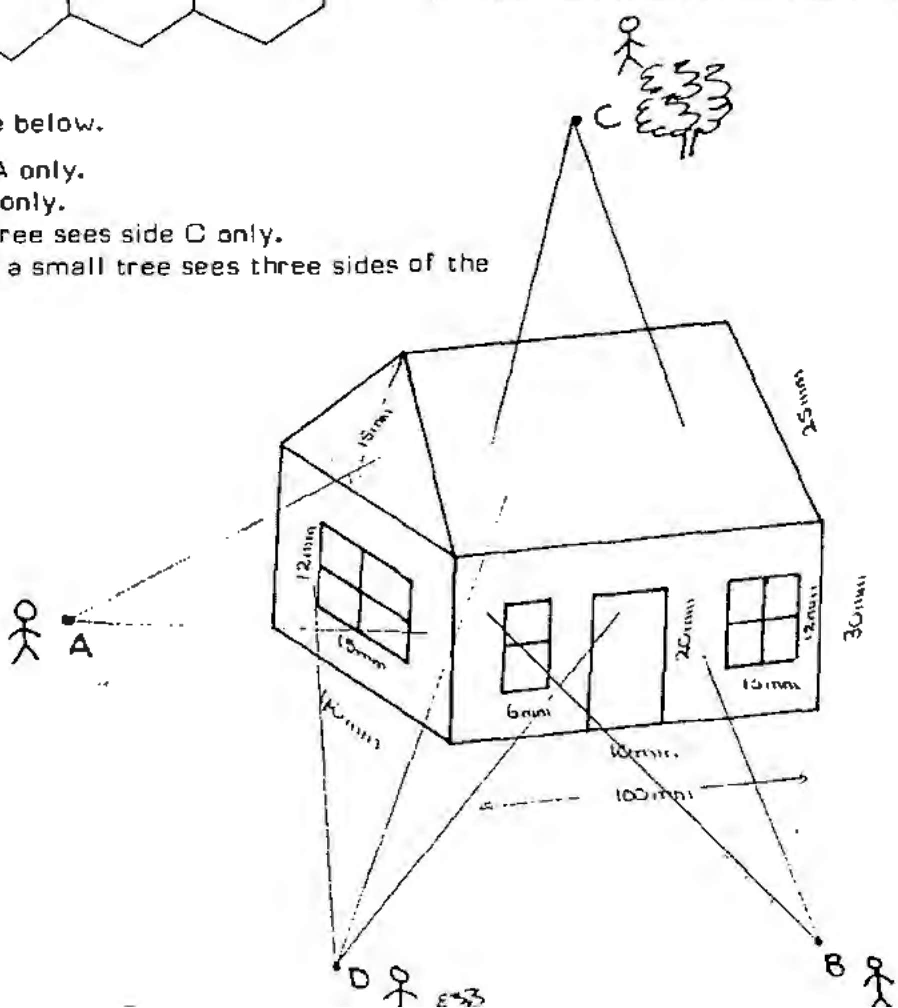
18. With what do you relate a number of the above figures when joined in this way?



Spider web
Ant hills
Bee honey cake
Uncertain

19. Study the figure below.

Sipho sees side A only.
Vusi sees side B only.
Thomseon on a tree sees side C only.
Albert on top of a small tree sees three sides of the house.



20. Choose the correct answer by marking a cross (X) on the space provided.

(a) Side A in technical terms is called

Top view	Front view	Side view	Sipho view

(b) Side C is called

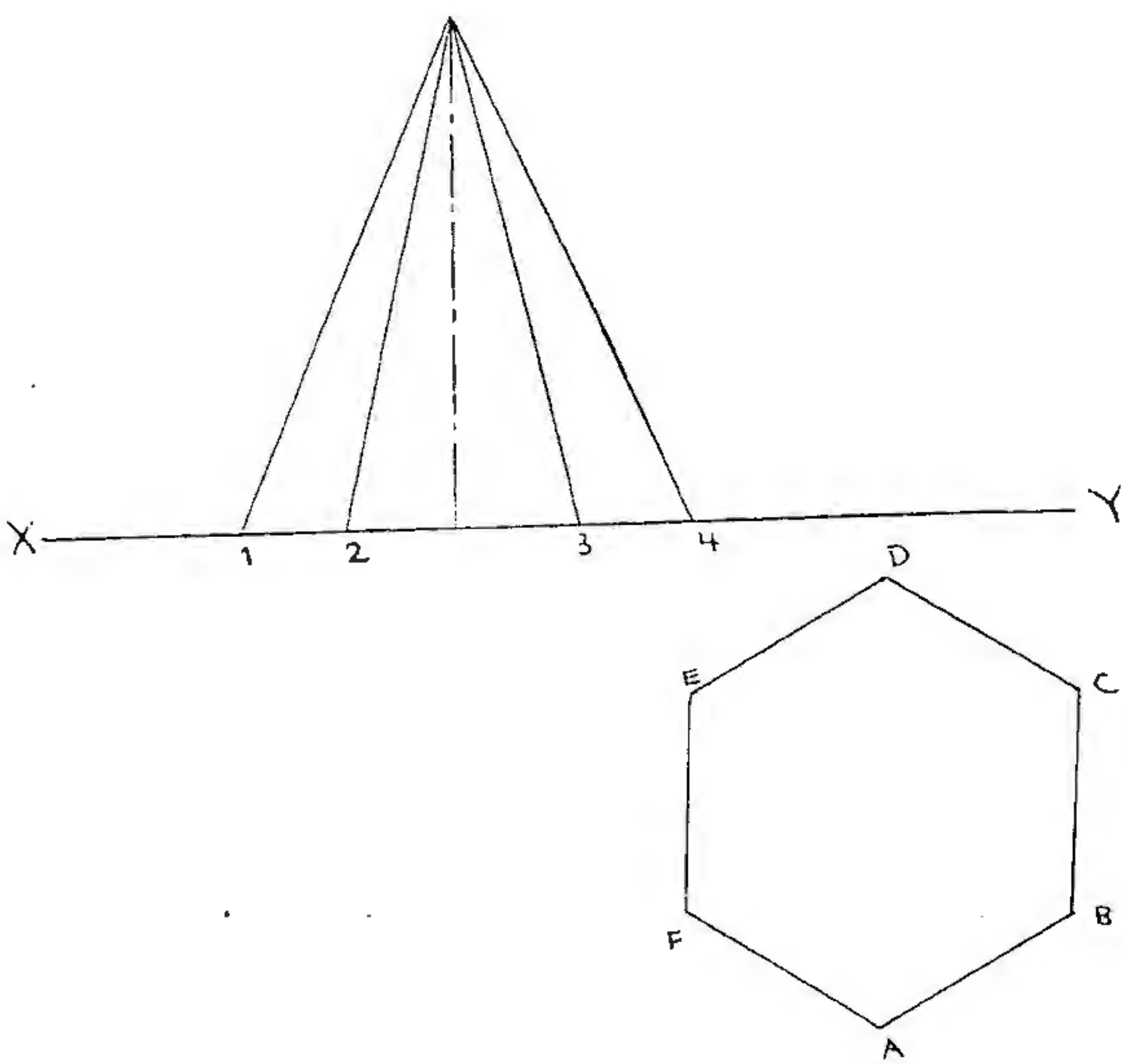
Top view	Front view	Side view	Thomson view

(c) Side B is called

Top view	Front view	Side view	Vusi view

21. Illustrate by means of the First Angle Orthographic side A, B and C of the figure provided.

22. Make a three dimensional representation of the sides seen by Albert from point "D".



23. Match the letter of the Top View with the appropriate sides of the Front View marked 1-4.

(a)	1	=	A	B	C	D	E	F
(b)	2	=	A	B	C	D	E	F
(c)	3	=	A	B	C	D	E	F
(d)	4	=	A	B	C	D	E	F

APPENDIX C

PART C : OBSERVATION CHECKLIST DURING TECHNICAL DRAWING LESSONS

A cross (X) will be marked under numbers (1-5) according to the value that the researcher finds the teacher to be assigning to each of the following:

N.B. 1 = Lowest 5 = Highest

Standard: .... Date: ....

	1	2	3	4	5
1. Is the classroom environment conducive to the teaching and learning of Technical Drawing?					
2. Actualization of the previous knowledge. (a) Subject knowledge					
(b) Everyday experience					
3. Use of teaching aids/practical work or demonstrations					
4. Language usage (Technical Drawing terminology)					
5. How often does the teacher use the mother tongue words or phrases during lesson presentation?					
6. How does the teacher attach the pupils' concepts to transfer new concepts?					
7. Time spend by the teacher explaining and illustrating new subject matter					
8. Pupil involvement					
9. Correct representation and illustration on the chalk=board					
(a) Accuracy					
(b) Line work					
(c) Lettering					
(d) Tidiness					
(e) Dimensioning					
(f) Attitude towards drawing					
10. Classroom discipline in relation to the nature of Technical Drawing					
11. Individual attention to pupils					
12. Neatness of all classwork and drawing sheets					

Comments and recommendations

....

....

....

APPENDIX D

PART D : HEADS OF TECHNICAL DEPARTMENTS' QUESTIONNAIRE

1. Age: ....

2. Race: ....

3. Qualifications

   (a) Academic: ....

   (b) Professional: ....

4. Experience as a teacher in black schools: ....

5. Experience as H.O.D.

Nil	Less 5 yrs	More 5 yrs

6. Have you done Technical Drawing as a school subject at some stage in your educational career? Yes | No

7. Do you enjoy listening to Technical Drawing lessons? Yes | No

8. What is of great interest to you in the Technical Drawing lesson?

   ....

   ....

9. What is the most important consideration for admission of pupils to Technical Education?

   - [ ] Results of standardized test
   - [ ] Mathematics marks obtained in standard 5
   - [ ] Any pupil who wishes may enrol in the Technical Education programme offered
   - [ ] Other considerations

   Specify: ....

   ....

10. Indicate the approximate time you spent participating in the following:

	Full period	Half period	1/4 period	Not at all
(a) Visit to Technical Drawing class				
(b) Checking exercises of pupils				
(c) Checking the teacher's progress with the work programme				
(d) Discussing syllabus contents with Technical Drawing teachers				
(e) Discussing problems which teachers experience with pupils				

11. What criteria do you use to select Technical Drawing teachers?

☐	Academic and professional qualifications
☐	Interest of the teacher in the subject
☐	Experience of the teacher in the subject
☐	Other considerations

Specify: ....

....

12. Do you think the Technical Drawing syllabus is defined with clear quidelines especially for inexperience teachers?

Yes	No

13. What will you do if a Technical Drawing teacher approach you with the syllabus interpretation problem at your school?

☐	Refer him to other Technical Drawing teachers
☐	Help him where possible
☐	It is not part of my duty to do so
☐	Other actions

Specify: ....

....

14. What do you do to promote and encourage pupils' interest in the learning of Technical Drawing? ....

....

15. Do Technical Drawing teachers have enough teaching aids (charts, models, etc.) in the teaching of Technical Drawing?

Yes	No

16. If Yes, what makes you to think so? ....

....

17. If Not, what do you do about the matter as an authority? ....

....

....

First Angle Projection

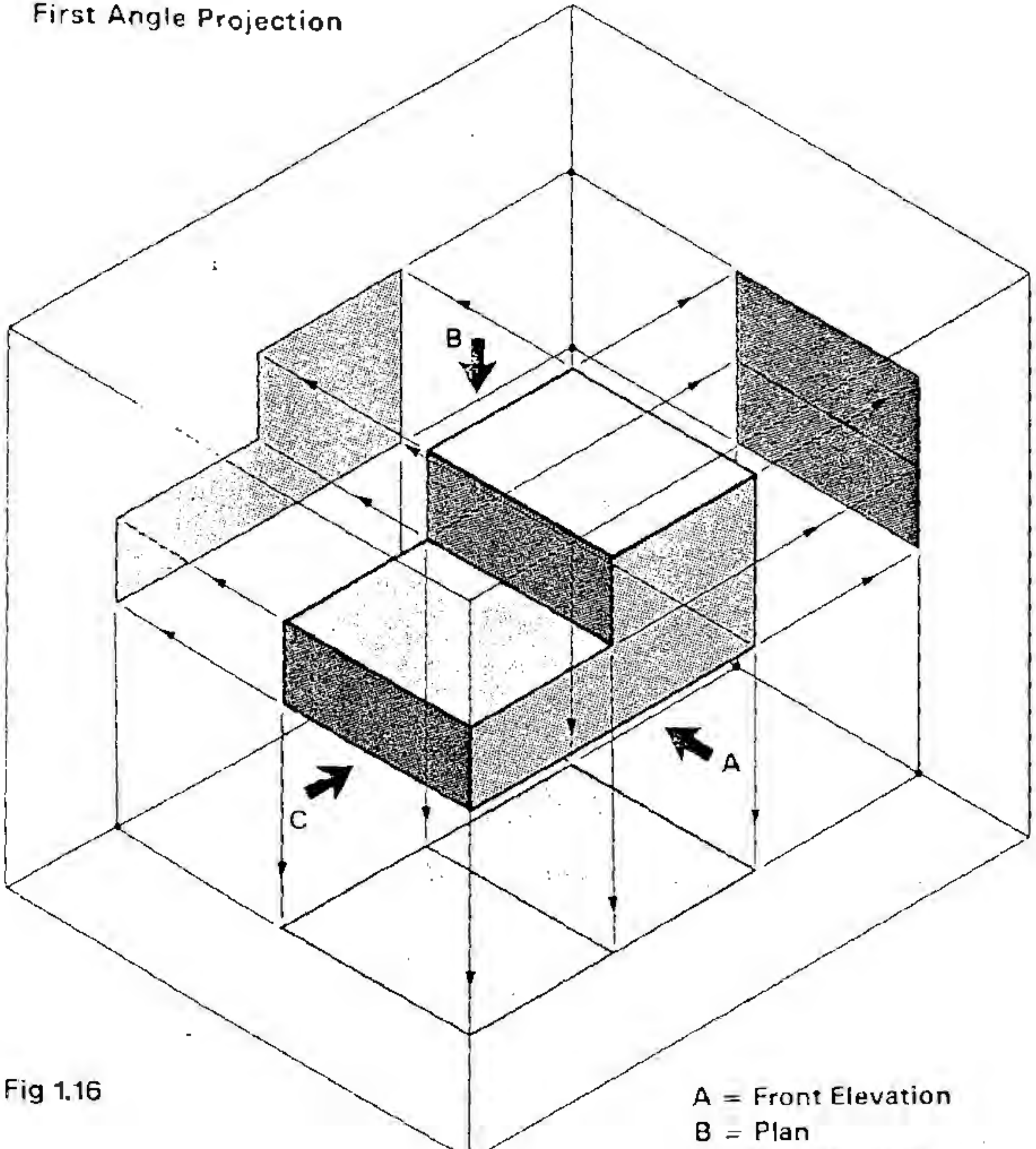


Fig 1.16

A = Front Elevation
B = Plan
C = End Elevation

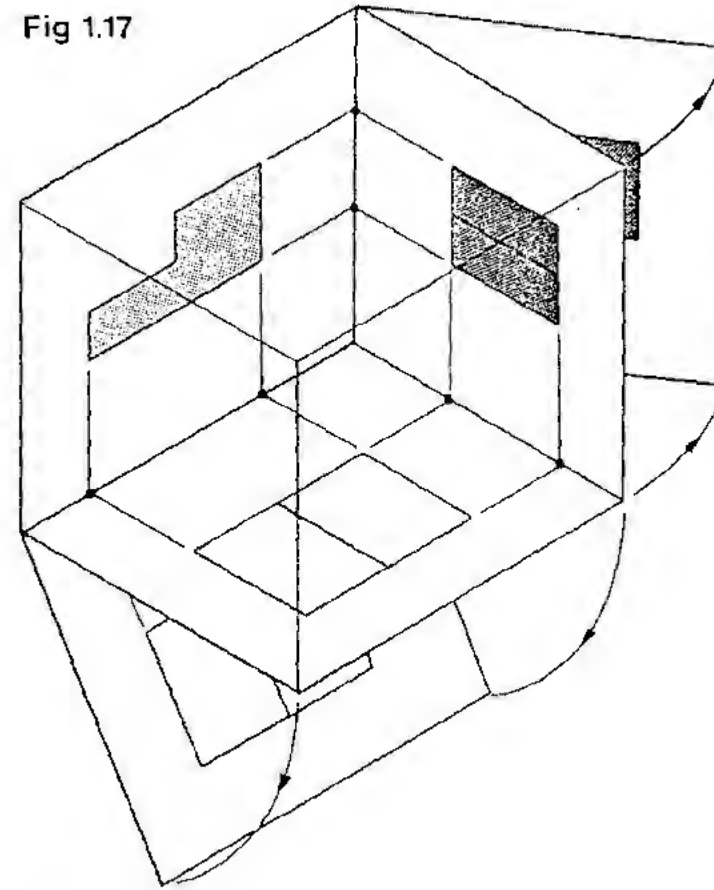


Fig 1.17

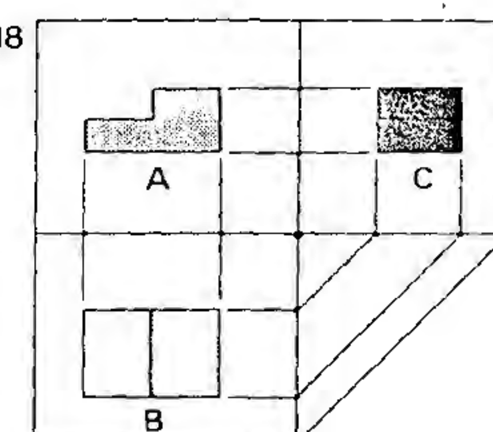
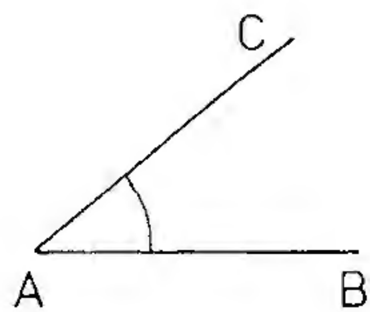
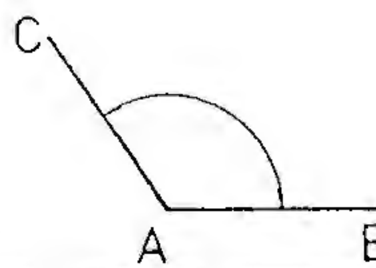
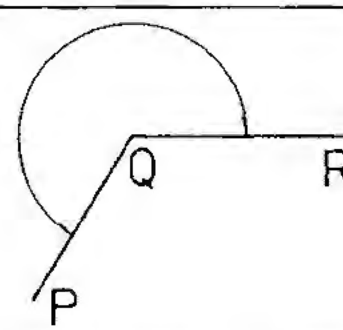
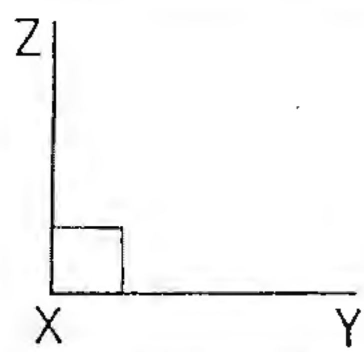


Fig 1.18

APPENDIX F

GEOMETRICAL CONSTRUCTIONS : STANDARD 6

TYPE	DEFINITION	DRAWING
The acute angle: Derivation: From the Latin - acutus - to sharpen	An acute angle is an angle the magnitude of which is greater than 0° but less than 90°	
The obtuse angle: Derivation: From the Latin - obtundo - to blunt	An obtuse angle is an angle the magnitude of which is greater than 90° but less than 180°	
The reflex angle: Derivation: From the Latin - flexio - to bend	A reflex angle is an angle the magnitude of which is greater than 180° and less than 360°	
The right angle: Derivation: From the Latin - rectus - means upright from the base when applied to mathematics	A right angle is an angle the magnitude of which is exactly 90°	

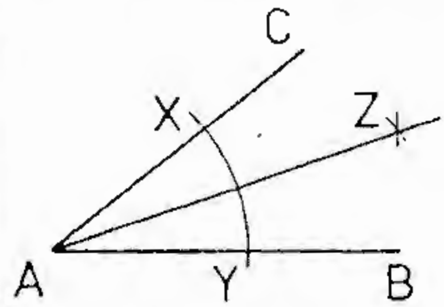
PROBLEM 1 : TO BISECT A GIVEN ANGLE

Given: Angle CAB

Method:
With A as centre and any convenient radius strike an arc to find X & Y. With X & Y as centres, and the same radius, strike arcs to find Z.

Join AZ.

AZ is the bisector of CAB.



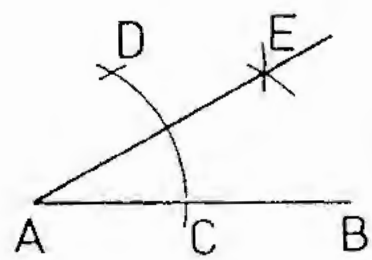
PROBLEM 2 : TO CONSTRUCT AN ANGLE OF 30°

Given: A straight line segment AB

Method

With A as centre and any convenient radius strike an arc to find C. With C as centre and the same radius as before strike an arc to find D. With C & D as centres and the same radius strike arcs to find E.

Angle BAE = 30°.

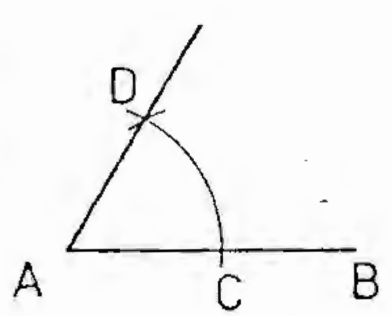


PROBLEM 3 : TO CONSTRUCT AN ANGLE OF 60°

Given: A straight line segment AB

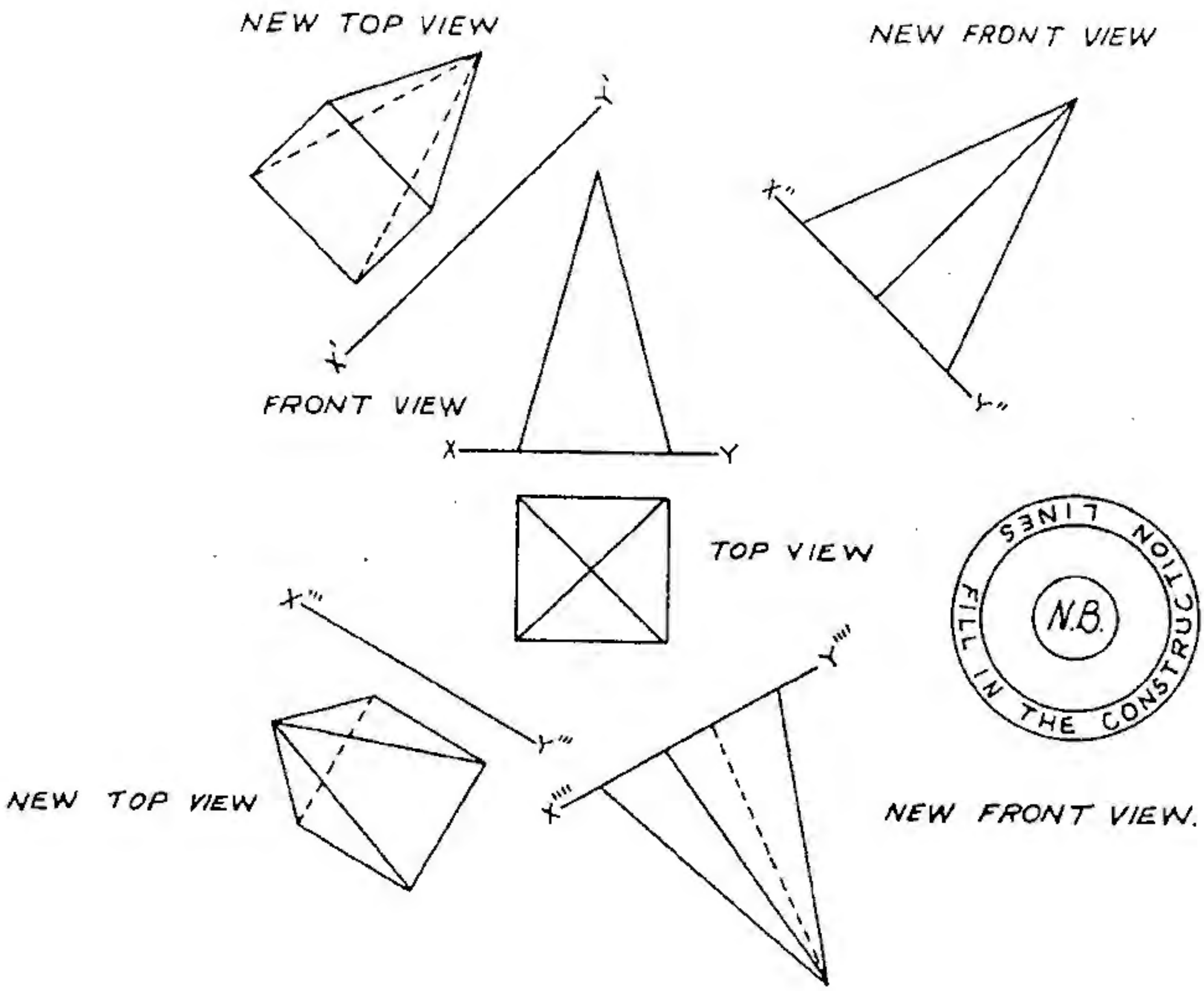
Method:
With A as centre and any convenient radius strike an arc to find C. With C as centre and the same radius strike an arc to find D.

Angle DAC = 60°.



THE DRAWING OF AUXILIARY VIEWS OR CHANGING THE GROUND LINE

(i) To obtain a **new top view** project, at right angles to your **new ground line**, from the "old" **front view**. Each point is then measured from the XY line to the **top view** and then set off from X'Y' or X'''Y''' to find the **new top view.**



(ii) To obtain a **new front view** project, at right angles to your **new ground line**, from your "old" **top view.** Each point is then measured from the XY line to the **front view** and then sett off from X'' Y'' or X'''' Y''''
to find the **new front view.**

DRAWING INSTRUMENTS AND THEIR USE

PROBLEM 1 : TO CONSTRUCT A SQUARE

Draw a line AB 7,5 mm long. At A and B draw vertical lines with the set-square. From A, with the slanting edge of the 45° set-square, draw a line cutting the vertical line from B in C. Draw CD with the tee-square.

Apply the following tests: 1. Measure each side of the square with the compasses, and write down the amount of any inaccuracy. 2. Draw the diagonal BD, and test whether it equals AC. 3. Place the set-square on the tee-square, and see whether the edge exactly coincides with BD. If it does not, then either the construction is inaccurate or the square is not true. 4. Measure both diagonals, and write down their lengths.

PROBLEM 2 : TO DESCRIBE A SQUARE ABOUT A CIRCLE

Describe a circle with a radius of 50 mm. Through the centre draw AB and CD perpendicular to each other. Through C and D draw parallels to AB, and through A and B (with the set-square) parallels to CD, giving the required square. Measure the sides, and note any inaccuracy. Through the centre, with the slanting edge of the 45° set-square, draw lines. If the set-square is true, and the construction accurate, these lines will be diagnoals, and will pass exactly through the corners of the square.

If the points A, C, B, D be joined, the inscribed square is obtained.

PROBLEM 3 : TO DESCRIBE AN OCTAGON ABOUT A CIRCLE

Describe a circle, and draw the diameters AB, CD, EF., GH as in Problem 2. Through the points C and D draw parallels to GH, and through G and H parallels to EF. Test the lengths of the sides of the octagon, and the lenghts of the arcs AE, EC, etc. Practice this exercise several times until sufficient accuracy is secured.

PROBLEM 4 : TO DRAW AN EIGHT-POINTED STAR

Describe a circle, and draw the four diameters as in Problem 3. Draw the square ACBD with the slanting edge of the 45° set-square. Draw the square EGFH with the tee-square and set-square. Thicken in the figure as shown.

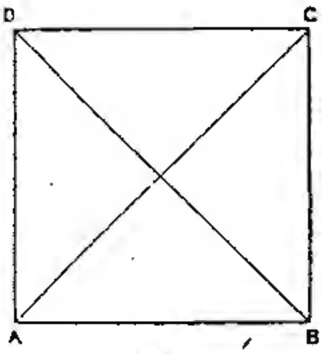
PROBLEM 5 : TO CONSTRUCT AN EQUILATERAL TRIANGLE

Draw AB 75 mm long. With the 60° set-sqaure draw AC and BC, placing the angle of 60° on the tee-square. The tee-square should be below the line AB., so that the lines drawn with the edge of the set-square may pass exactly through the points A and B. Test the three sides for any inequality. Draw CD perpendicular to AB. With centre D and radius DA describe a semicircle. If the construction is accurate, the arc will terminate at the point B.

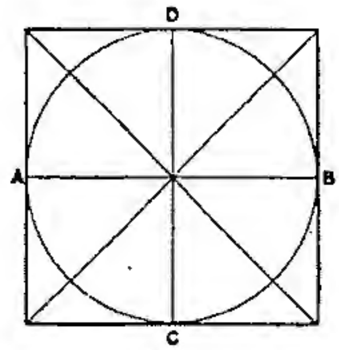
PROBLEM 6 : TO CONSTRUCT A REGULAR HEXAGON ON A GIVEN BASE

Draw AB 50 mm long. From A and B draw AD and BC with the 60° set-square. Reverse the square, and draw BE and AF. Throught the inter-section of AD and BE draw FC parallel to AB. Draw FE parallel to AD, and CD parallel to BE. From E draw ED parallel to 'FC. If accurate, the line ED will meet CD exactly on the diagonal AD. Test the three diagonals.

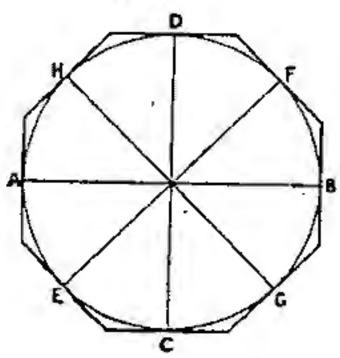
DRAWING INSTRUMENTS AND THEIR USE



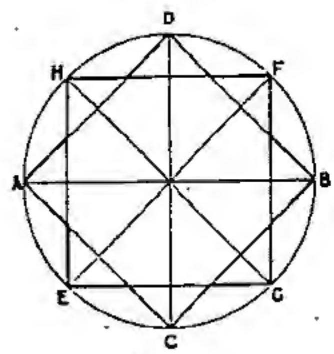
Prob. 1.



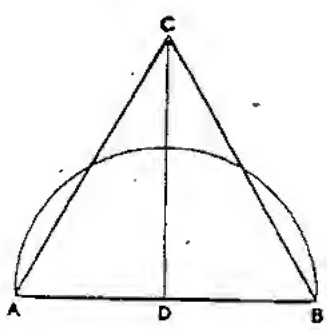
Prob. 2.



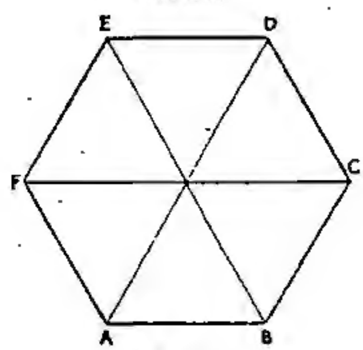
Prob. 3.



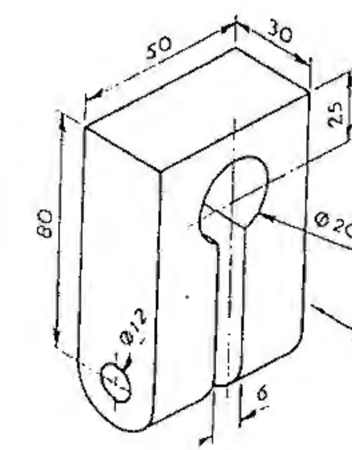
Prob. 4.



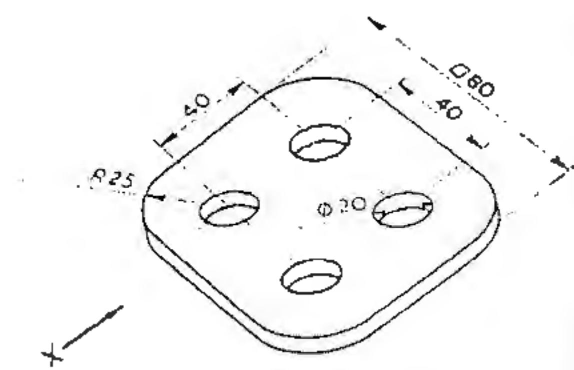
Prob. 5.



Prob. 6.



Draw the front view in correct first angle orthographic projection of the figure above, when viewed in the direction of arrow X. Also project the top view and left view. Show the symbol for first angle projection and insert at least five dimensions. Use any convenient scale and indicate which schale you have used.



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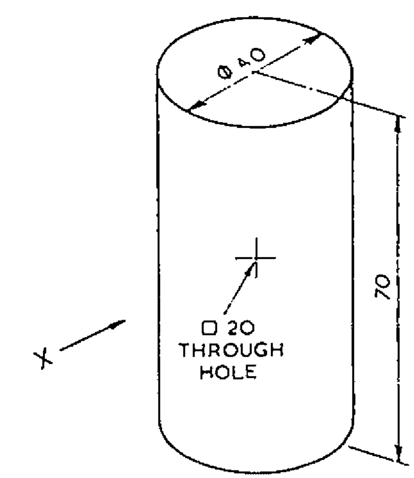

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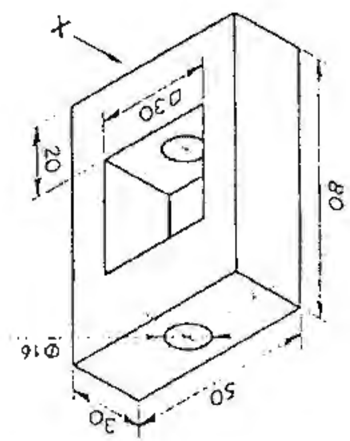

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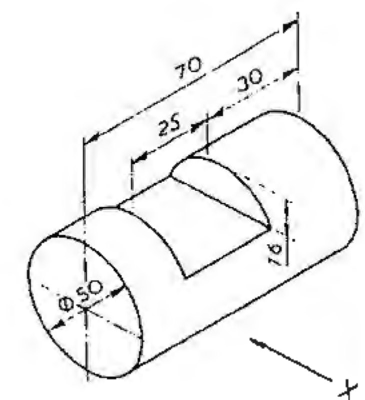

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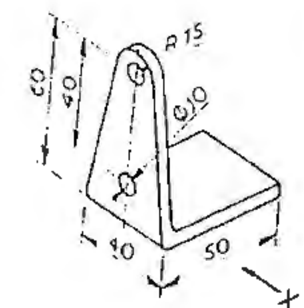

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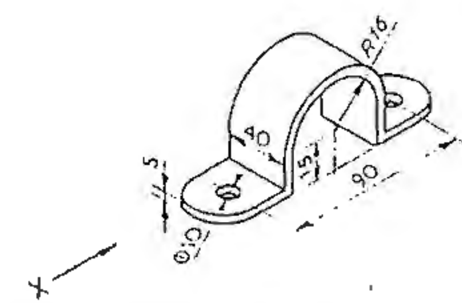
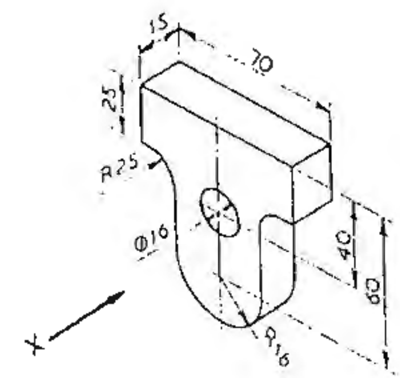
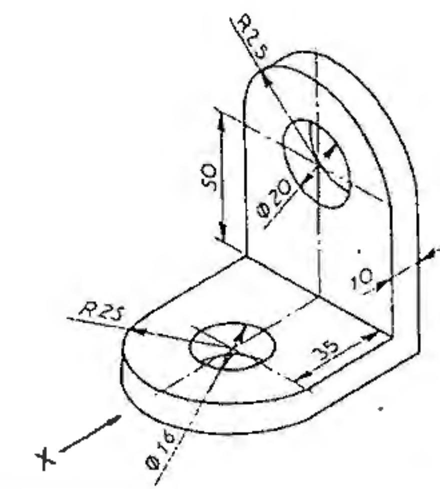


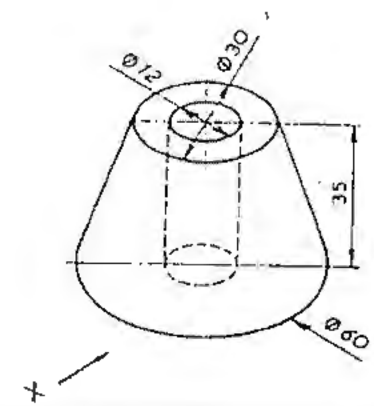
Draw the front view in correct first angle orthographic projection of the figure shown above, when viewed in the direction of arrow X. Also project the top view and left view. Show the symbol for first angle projection and insert at least five dimensions. Use any convenient schale and indicate which scale you have used.



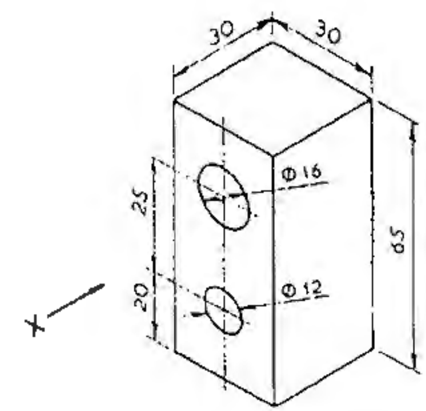
Draw the front view in correct first angle orthographic projection of the figure shown above, when viewed in the direction of arrow X. Also project the top view and left view. Show the symbol for first angle projection and insert at least five dimensions. Use any convenient schale and indicate which scale you have used.



Draw the front view in correct first angle orthographic projection of the figure shown above, when viewed in the direction of arrow X. Also project the top view and left view. Show the symbol for first angle projection and insert at least five dimensions. Use any convenient schale and indicate which scale you have used.



Draw the front view in correct first angle orthographic projection of the figure shown above, when viewed in the direction of arrow X. Also project the top view and left view. Show the symbol for first angle projection and insert at least five dimensions. Use any convenient schale and indicate which scale you have used.



Draw the front view in correct first angle orthographic projection of the figure shown above, when viewed in the direction of arrow X. Also project the top view and left view. Show the symbol for first angle projection and insert at least five dimensions. Use any convenient schale and indicate which scale you have used.

APPENDIX H

TIME: 4 Hours

MARKS: 300

REQUIREMENTS:

A2 sheets of drawing paper
Drawing instruments
Scale rule
Set squares
French curves

INSTRUCTIONS:

1. Draw on one side of the drawing paper only.

2. Do not answer more than two questions on one drawing sheet.

3. ANSWER ANY SIX QUESTIONS.

4. Number your answer exactly as the questions are numbered.

5. Print your name and group in the bottom right-hand corner of your answer sheets.

N.B.:

(a) Unless otherwise stated, all diagrams given and all answers are to be in first angle orthographic projection.

(b) H.P. = Horizontal plane

V.P. = Vertical plane

1. Refer to figure 1.

The figure shows the front view and left side view of three pieces of straight wire, joined at D as shown, and standing on the HP. Draw the two given views and project a top view. By construction determine:

(a) the total lenght of wire used;

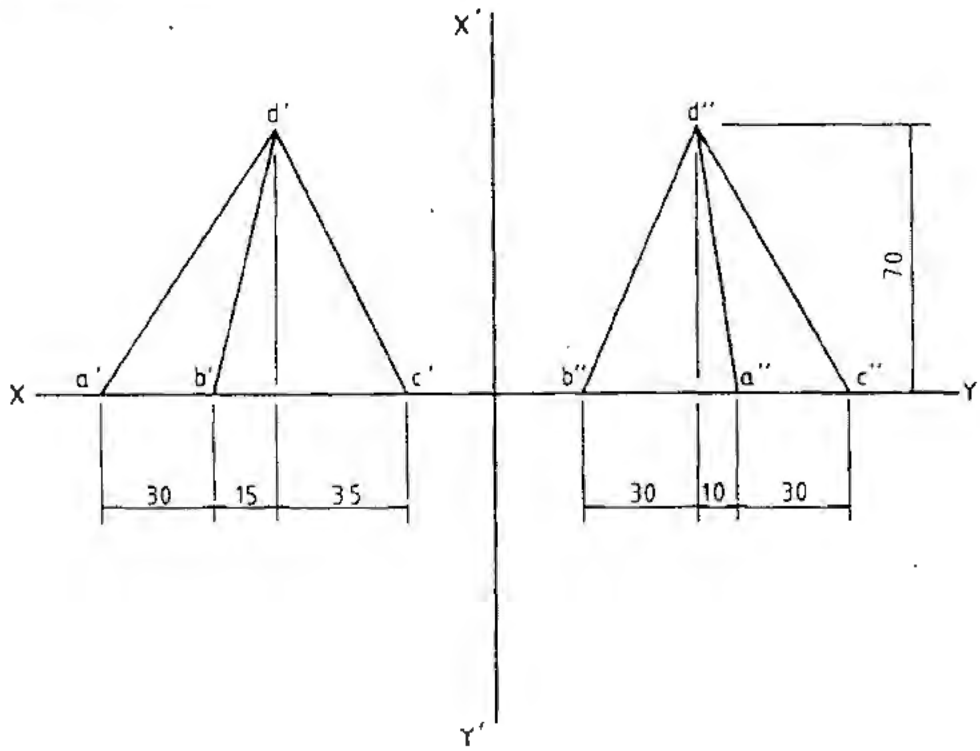
(b) the true inclination of DC to the HP;

(c) the true inclination of DB to the VP; and

(d) the true inclination of DC to the side (auxiliary) vertical plane.

Tabulate your answers neatly below your drawing. (50)

FIGURE 1



2. A triangular lamina ABC is positioned such that the projector of A lies 55 mm to the left of the projector of B while the projector of C lies 38 mm to the right of the projector of B.
A lies 65 mm above the HP and in the VP.
B lies 10 mm above the HP and 70 mm in front of the VP.
C lies 45 mm above the HP and 30 mm in front of the VP.

Draw the projections of the lamina ABC.

By construction determine:

(a) the vertical trace of side AB;

(b) the true inclination of side BC to the VP;

(c) the horizontal trace of side BC; and

(d) the diameter of the inscribed circle to triangle ABC (first find the true shape of the triangle).

Tabulate your answer neatly below your drawing. (50)

3. The displacement of a wedge-shaped follower caused by a disc cam rotating in a clockwise direction is given in the following table:

Rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	360°
Displacement (in mm)	0	13	26	39	48	57	66	66	60	45	30	15	0

The rise or fall is uniform between each 30° rotation.

Draw the graph of displacement using a horizontal scale of 8 mm : 30° rotation of the cam.

Draw the profile of the cam given diameter = 20 mm and the minimum distance of the cam profile from the centre of the cam spindle = 30 mm.

The line of stroke of the folower passes through the centre of the cam spindle. (50)

4. Refer to figure 2.

The figure shows a line AB 74 mm long containing a point P such that AP = 15 mm.

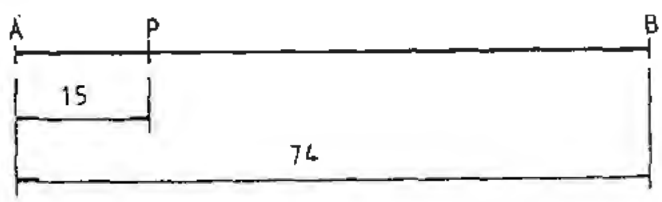
The line rotates in the plane of the paper about end A in a clockwise direction. During 1⅓ revolutions of the line, point P moves with uniform velocity along the line to end B.

Draw the locus of point P for this movement.

Show all necessary constructions.

How far is point P from end B after 400° rotation of the line? (50)

FIGURE 2



5. Refer to figure 3.

The figure shows a thread BC, 125 mm long, attached to a circle, centre A, of diamter 45 mm. Keeping the string taut, the thread is wound up clockwise around the circle until end C touches the circumference of the circle.

Draw the locus of end C of the string for this movement.

What is the length of the circumference of circle A?

Name the curve.

Show clearly all necessary construction lines and calculations. (50)

FIGURE 3

6. Figure 4 shows the front view of a right quilateral triangular pyramid with 60 mm base edges and 80 mm axis height resting with a base corner on the horizontal plane.

A base edge of the pyramid is parallel to the vertical plane and the axis is inclined at 60° to the horizontal plane.

The trace vt of a cutting plane which is perpendicular to the vertical plane is also shown.

Draw, full size, in first orthographic projection the following:

(a) the given front view;

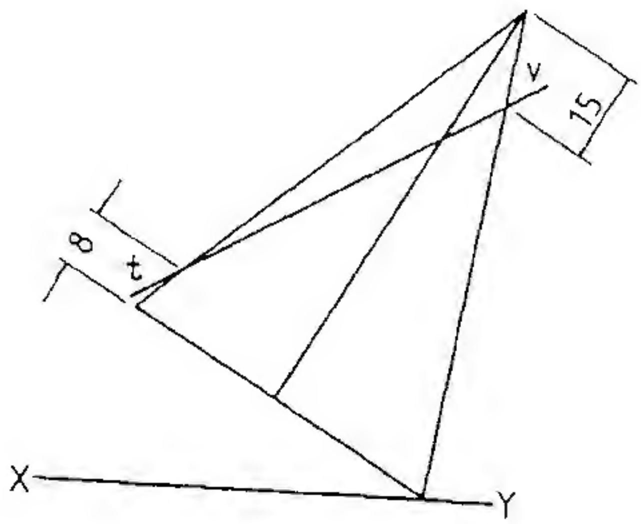
(b) a sectional top view;

(c) a sectional left view; and

(d) the true shape of the sectioned part.

Show all hidden details. (50)

FIGURE 4



7. Construct an epicycloid given the following information:

   (a) the diameter of the rolling circle which has a point P marked on the circumference is 50 mm;

   (b) the radius of the base circle is 100 mm; and

   (c) the rolling circle must complete one revolution.

   In the initial position the point P is in contact with the base circle. (50)

8. Figure 5 shows the top view of a right cylinder which has been pierced centrally by a right regular hexagonal hole which has 25 mm sides. The axis of the cylinder is parallel to the horizontal plane.

   The trace ht of a cutting plane which is perpendicular to the horizontal plane is also shown.

   Draw, full size, in first angle orthographic projection the following:

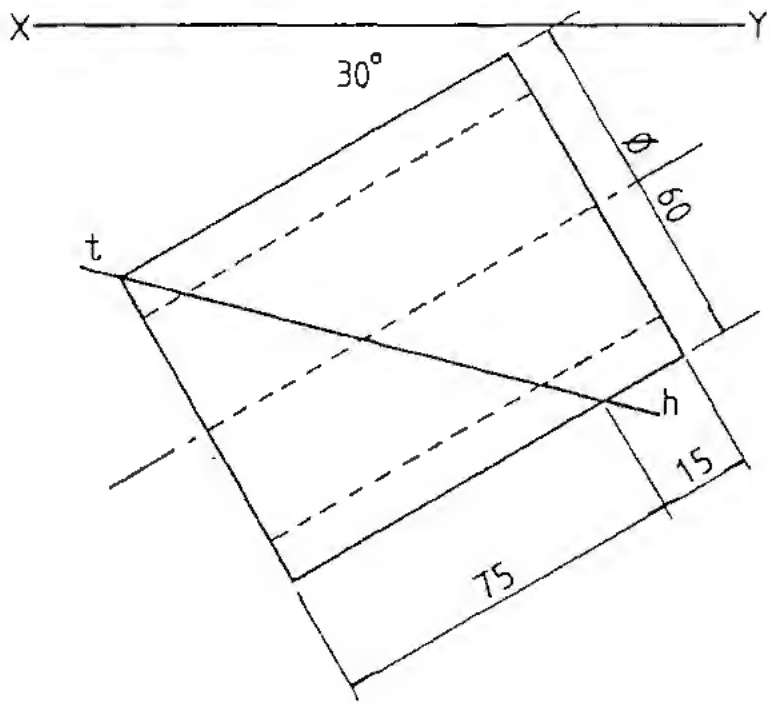
   (a) the given top view; and

   (b) a sectional front view.

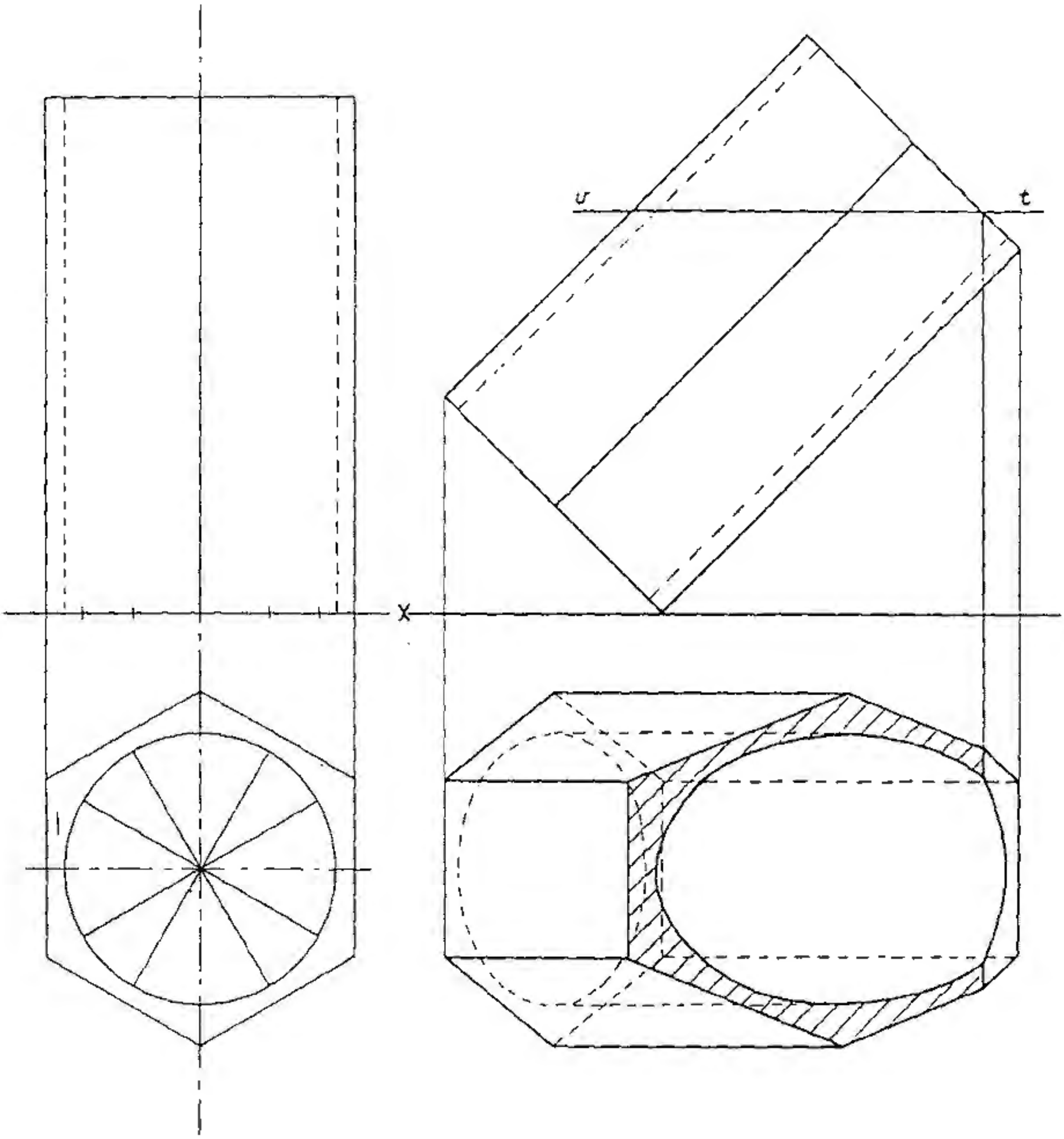
   Show all hidden details. (50)

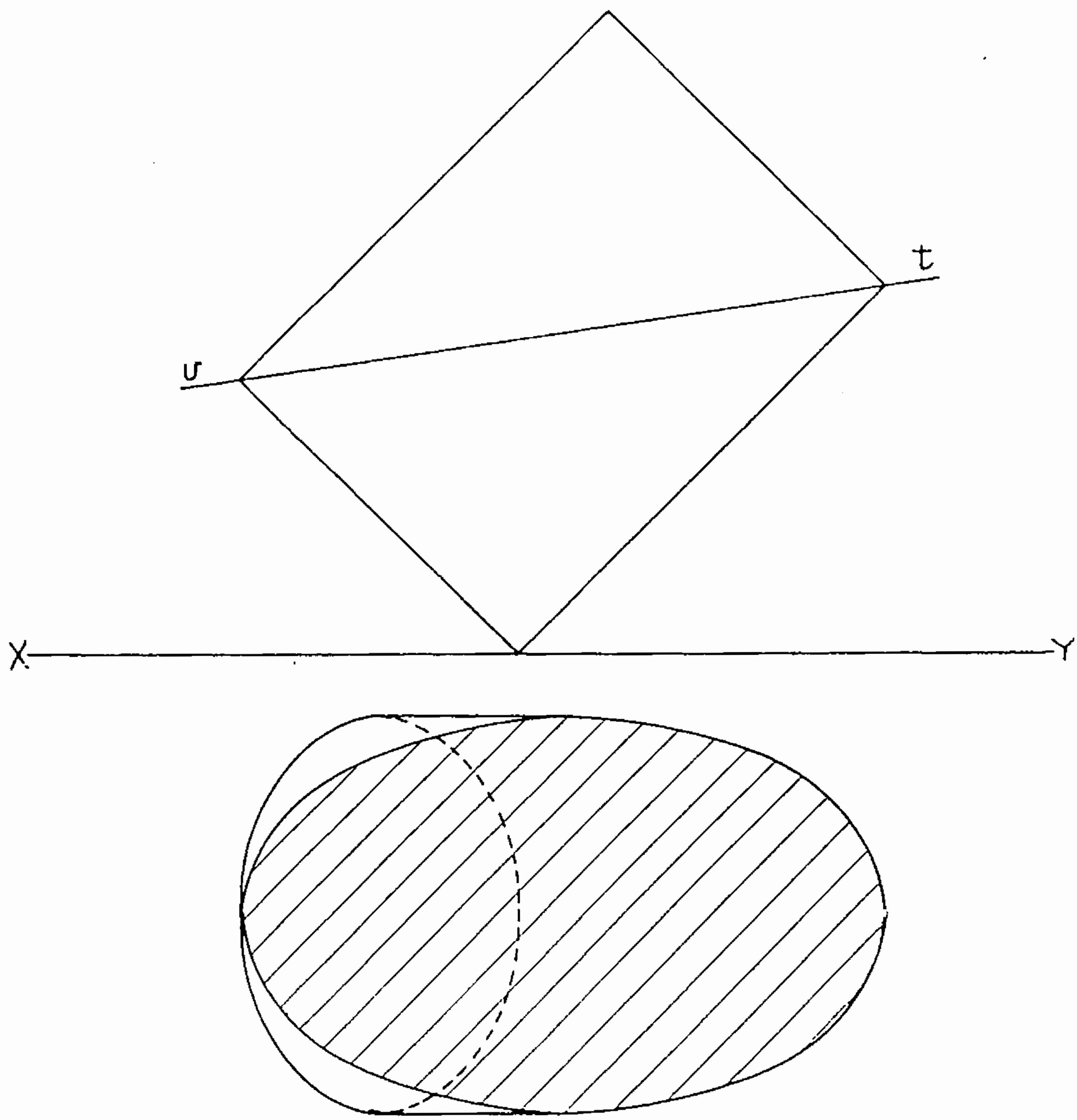
TOTAL (100)

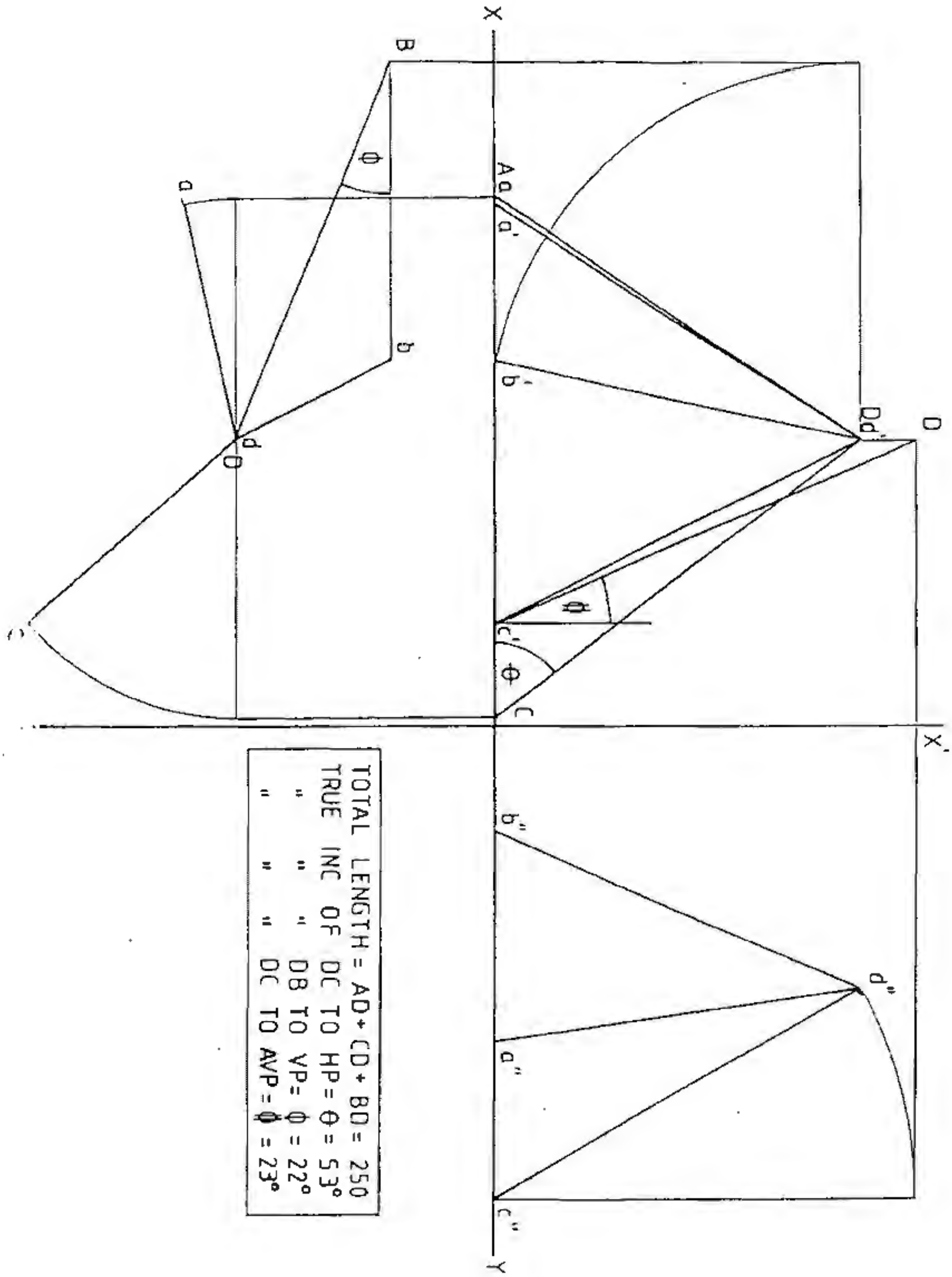
FIGURE 5

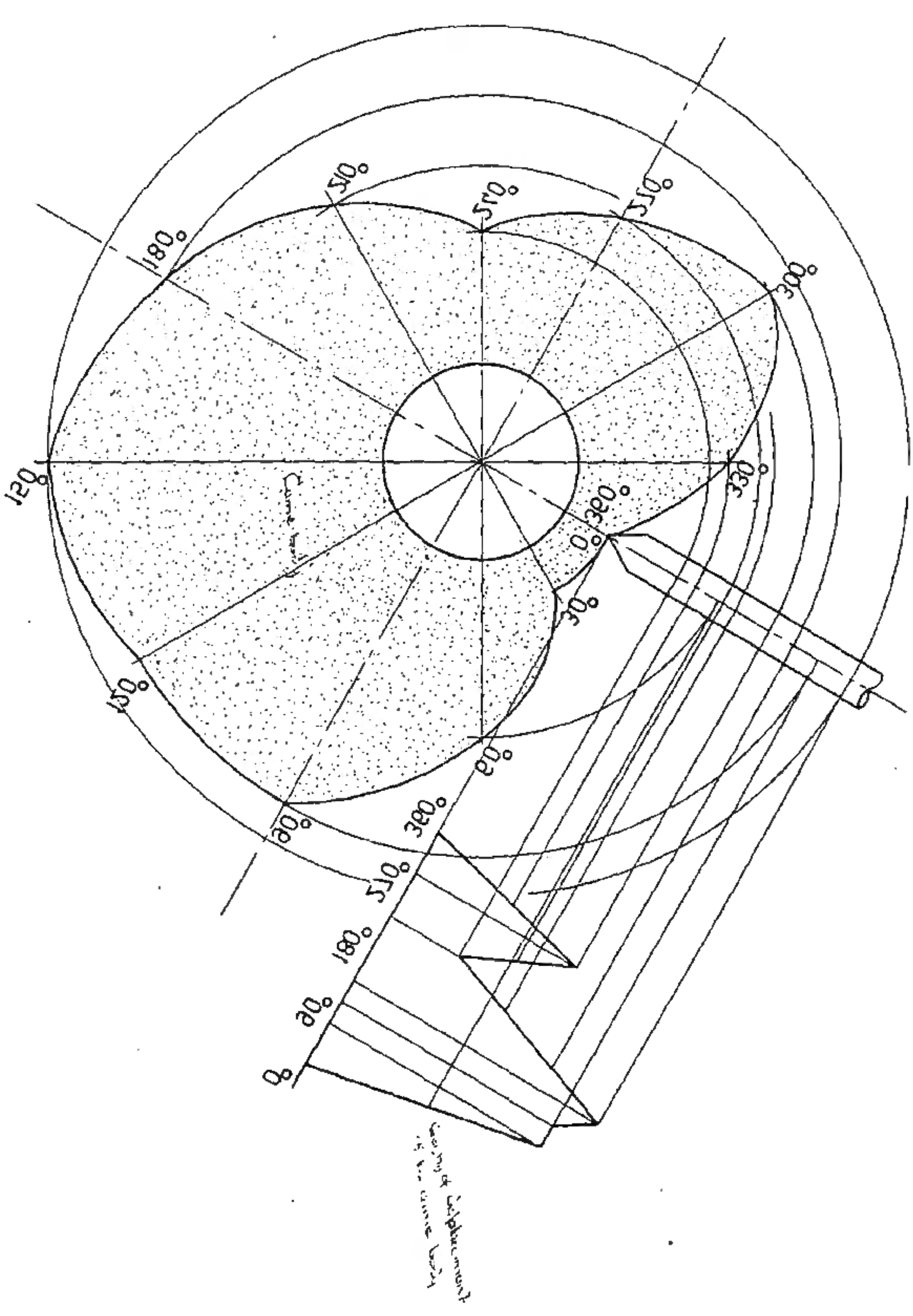


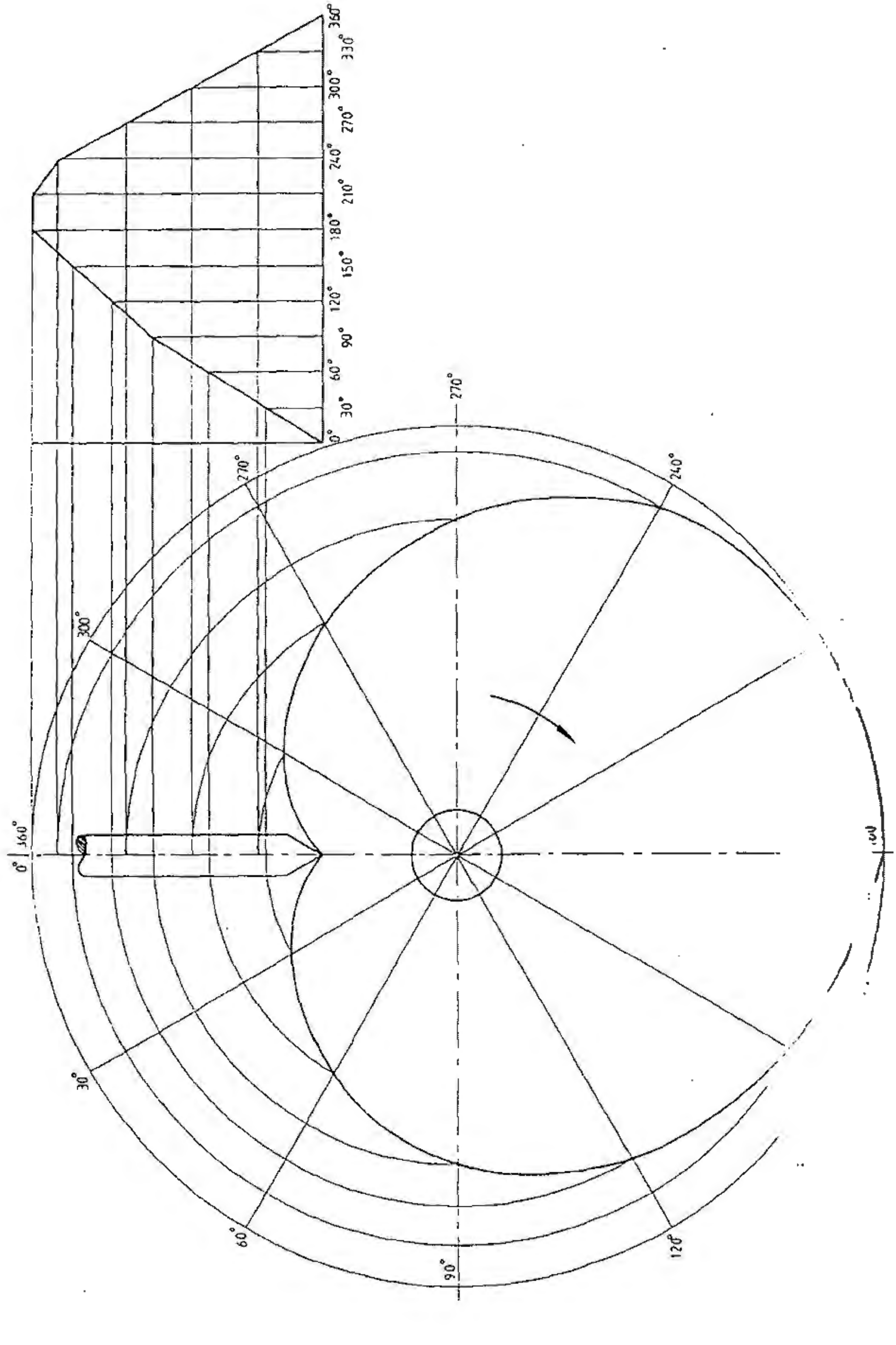
APPENDIX I

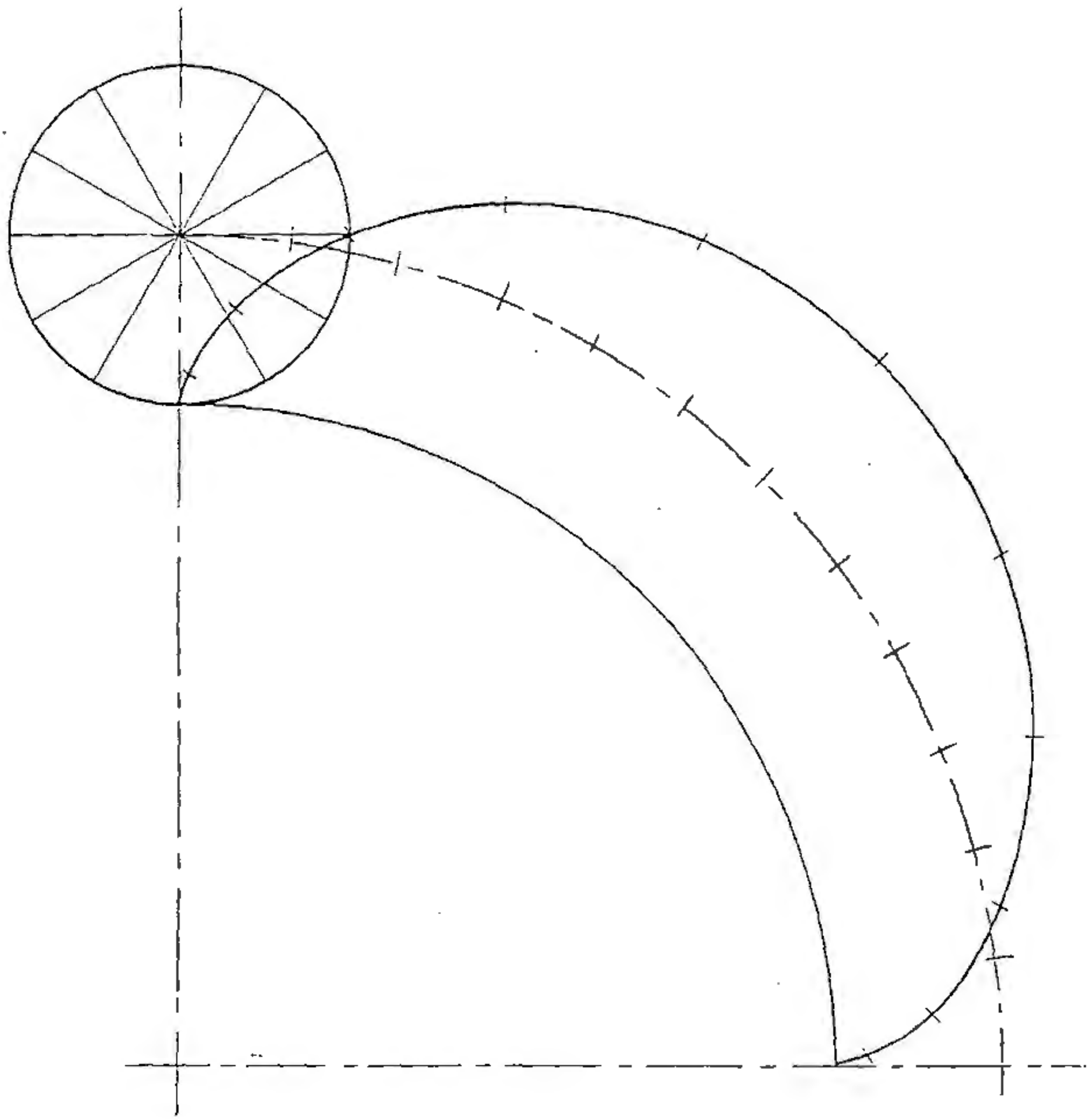


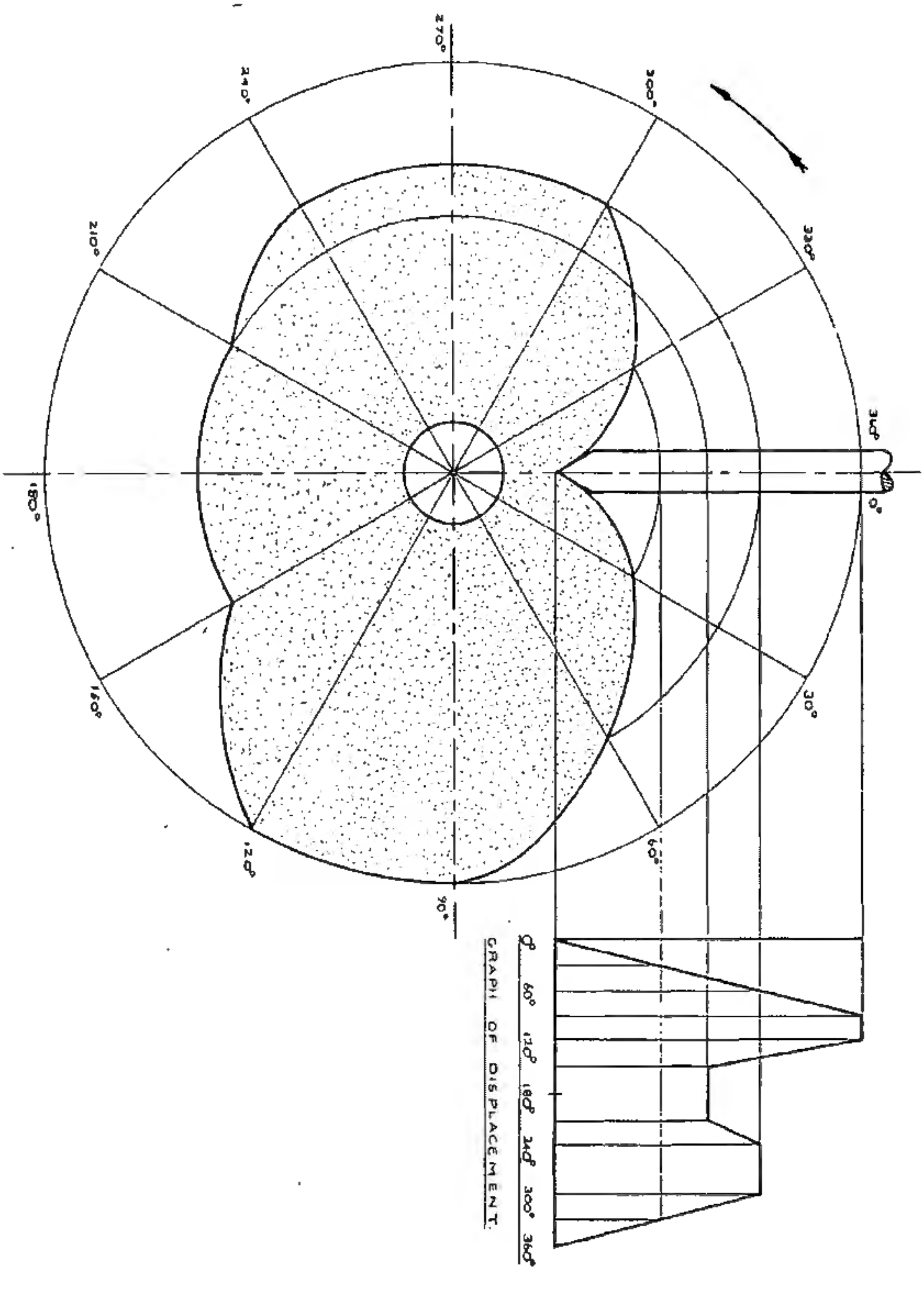

t
v
X
Y

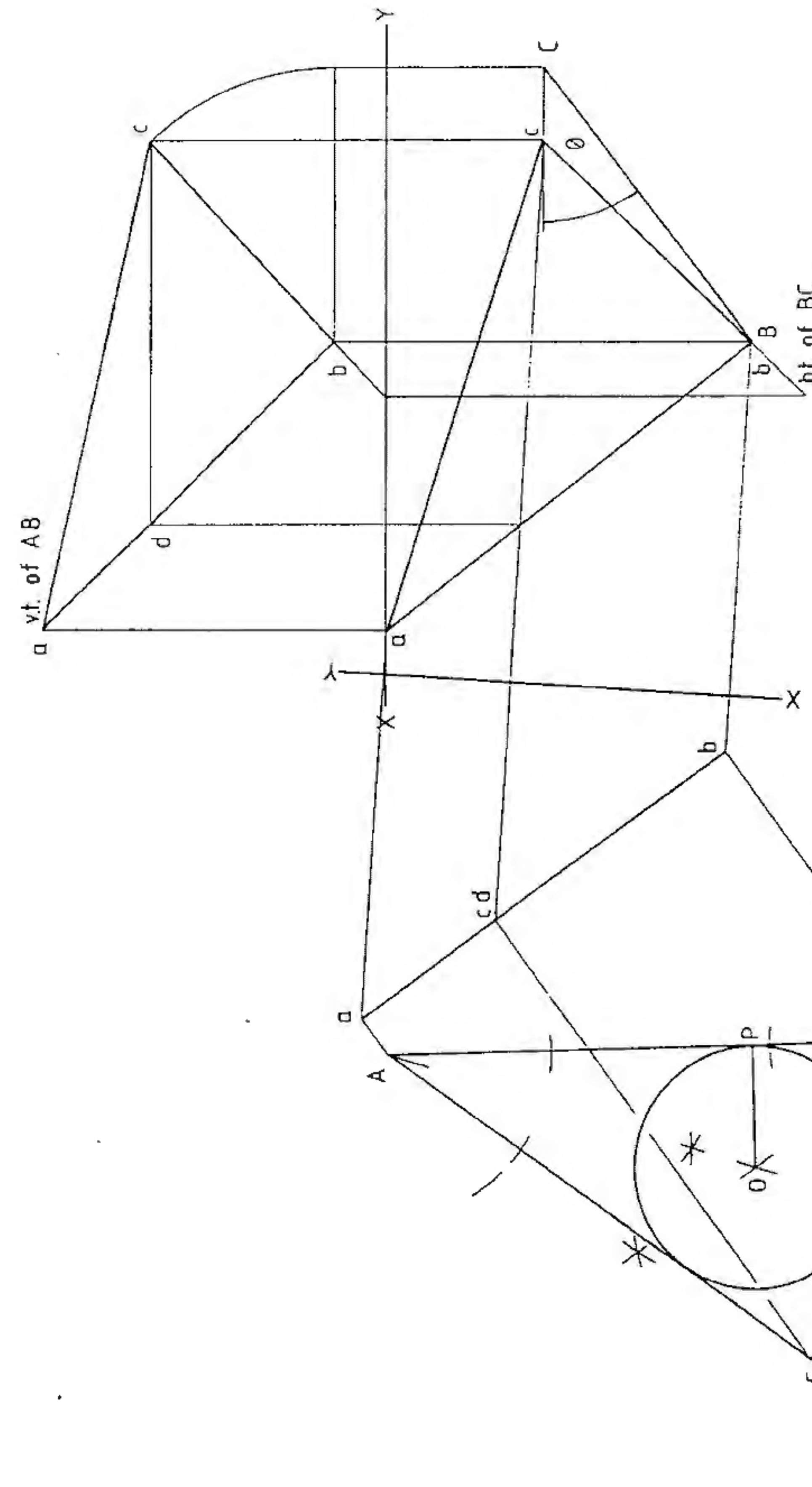

TOTAL LENGTH = AD+ CD+ BD= 250
TRUE INC OF DC TO HP= θ = 53°
" " " DB TO VP= ϕ = 22°
" " " DC TO AVP = ϕ = 23°
X
X'
Y
B
Aa
a'
b
b'
Dd'
D
d
c'
C
b"
d"
a"
c"



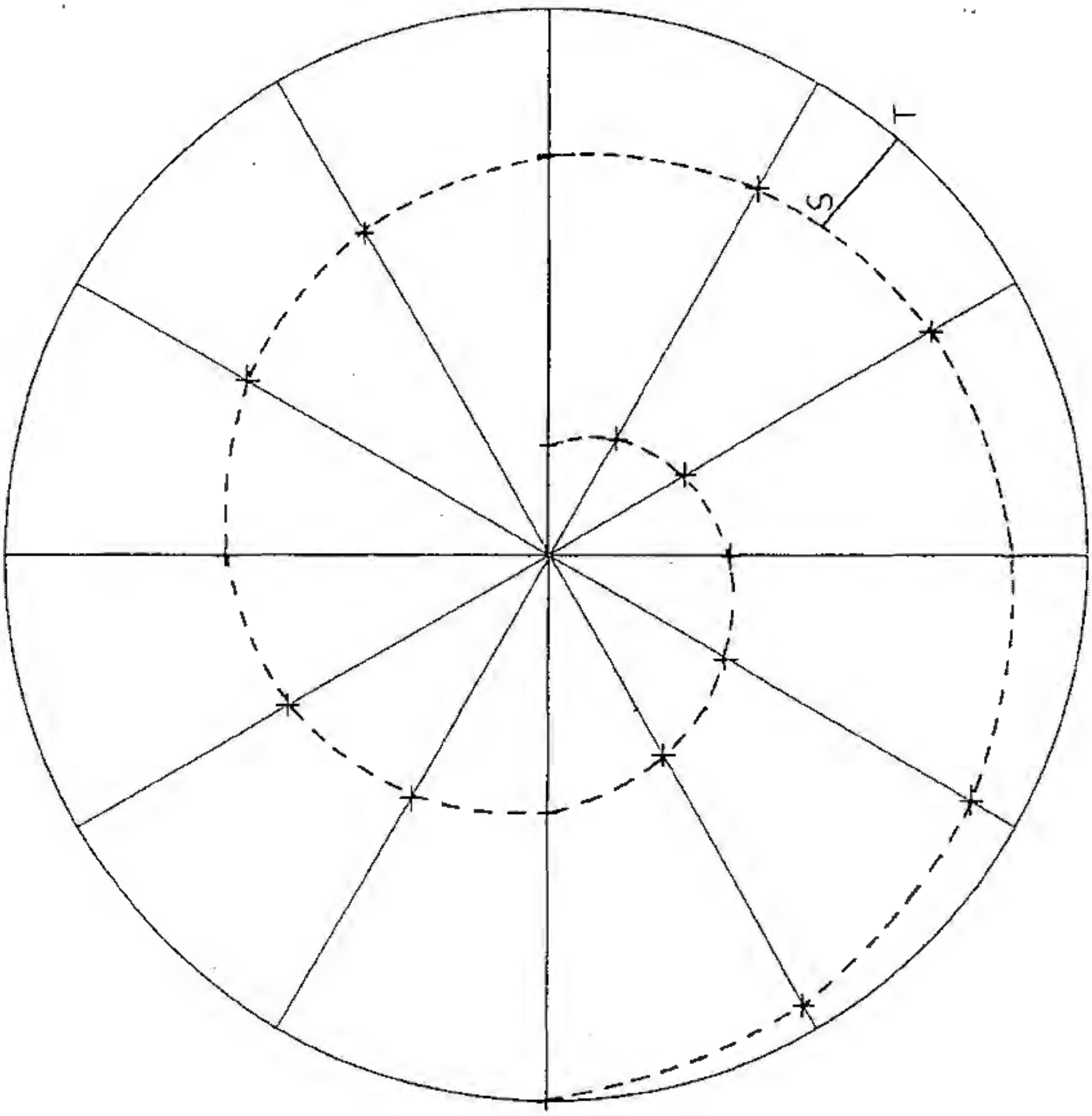

0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°
0°
360°
30°
60°
90°
120°
180
240°
270°
270°
300°

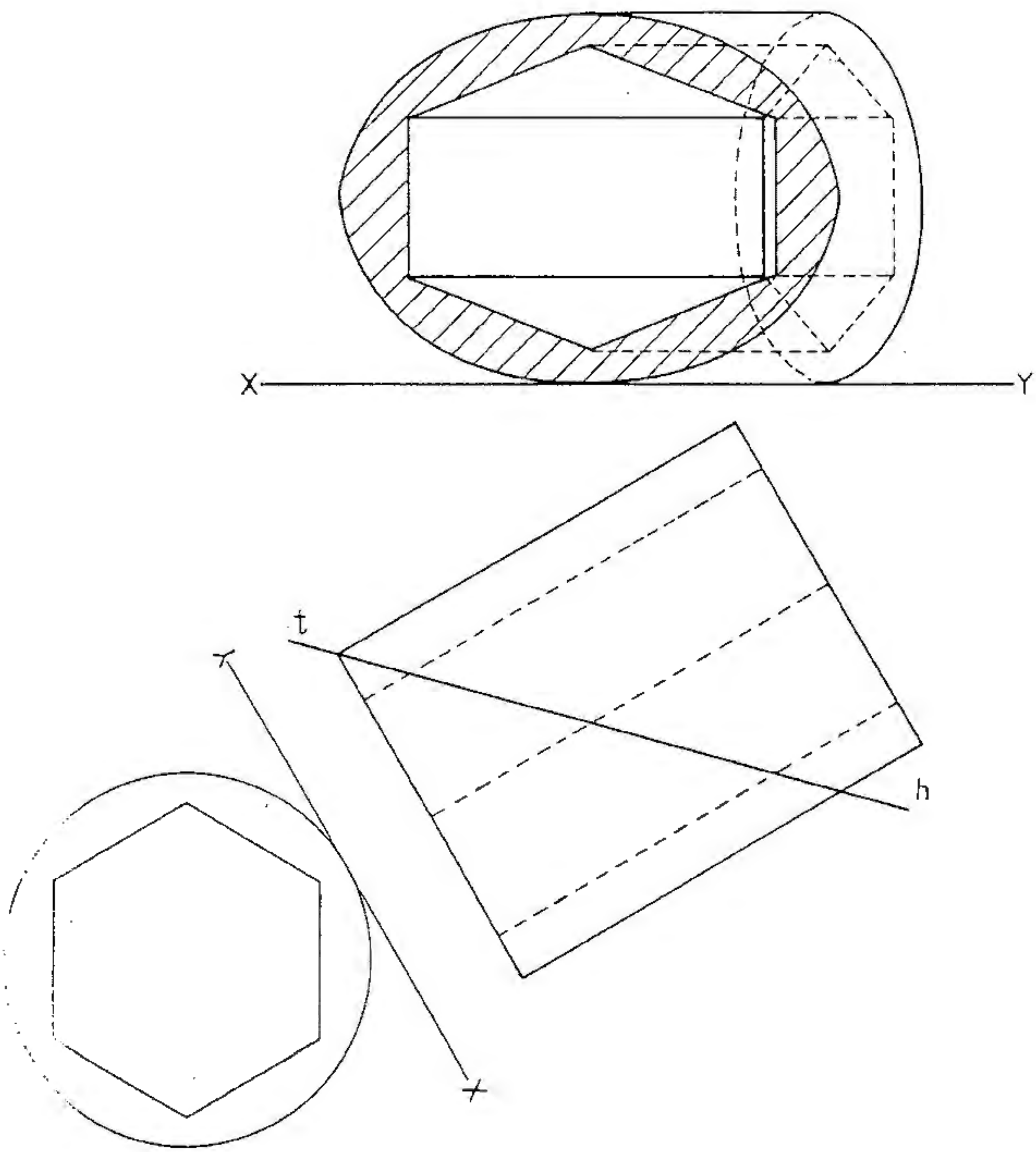


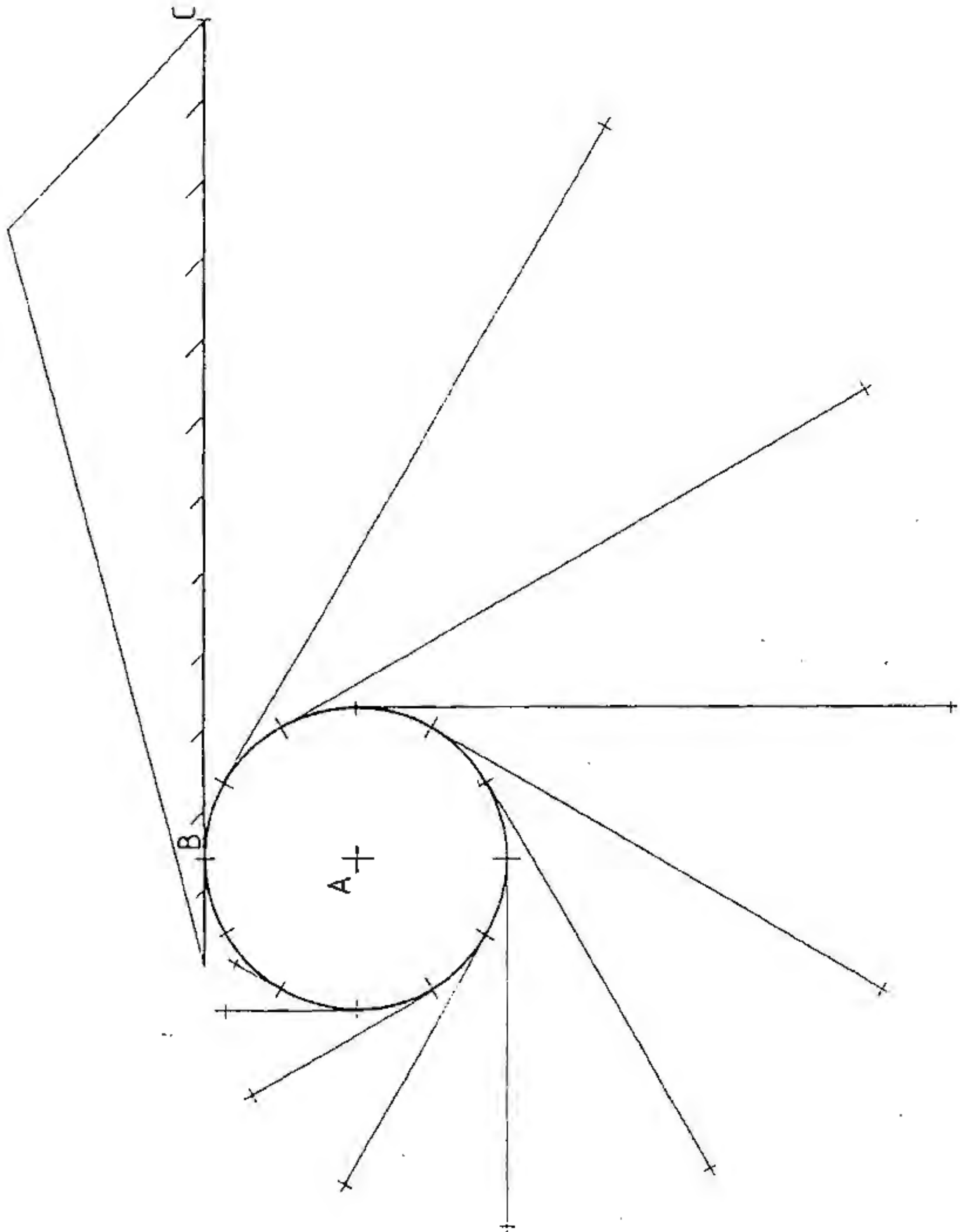

270°
240°
300°
210°
330°
180°
0°
150°
30°
120°
60°
90°
0° 60° 120° 180° 240° 300° 360°
GRAPH OF DISPLACEMENT.



b. TRUE INC. OF BC TO V.P. = Ø = 38°
d. RADIUS OF INS. CIRCLE = OP = 23


T
S


X
Y
t
h
X
Y


C
B
A

APPENDIX I

DIAGRAM 2

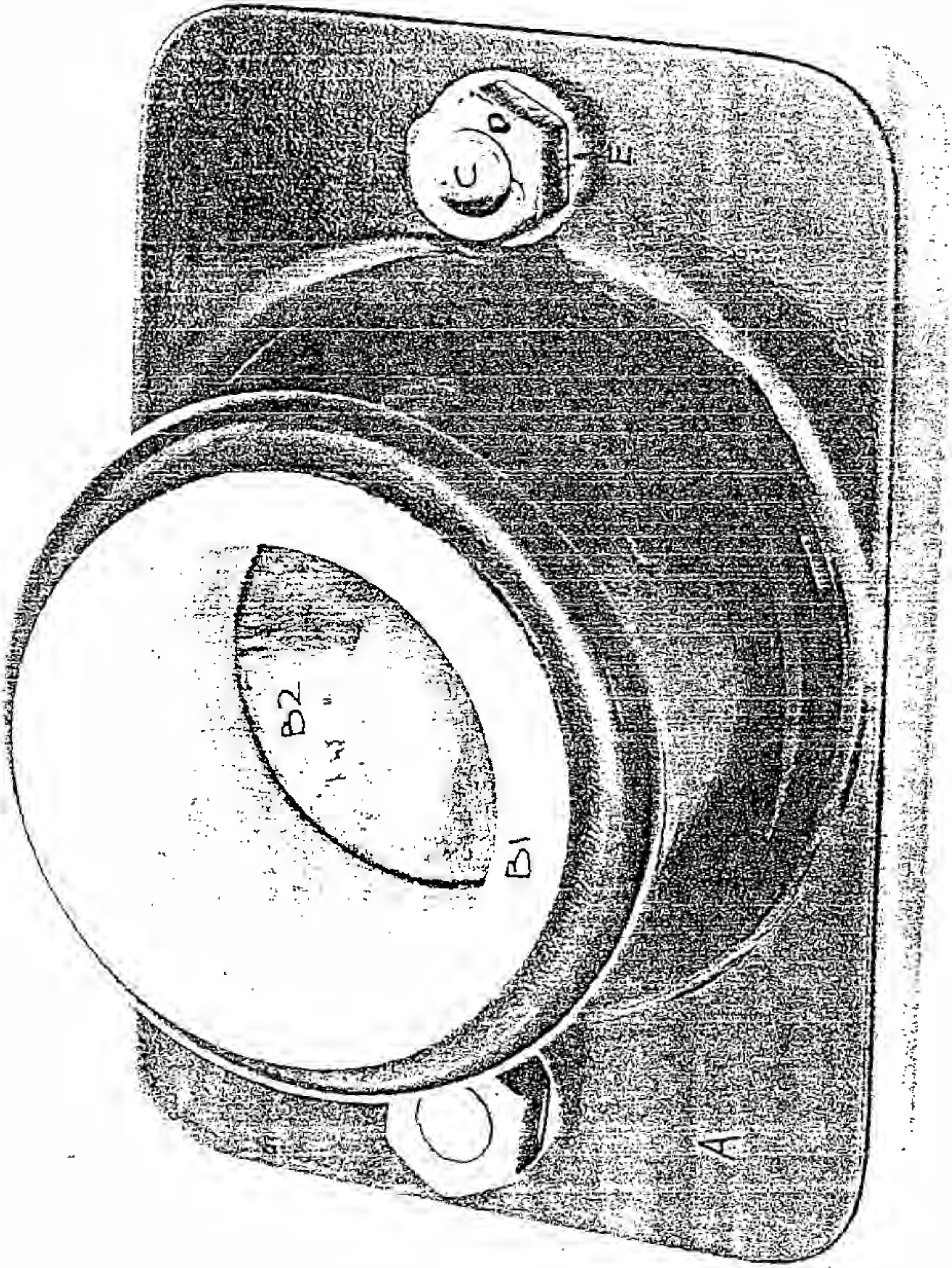


DIAGRAM SHEET 3
DIAGRAMVEL 3

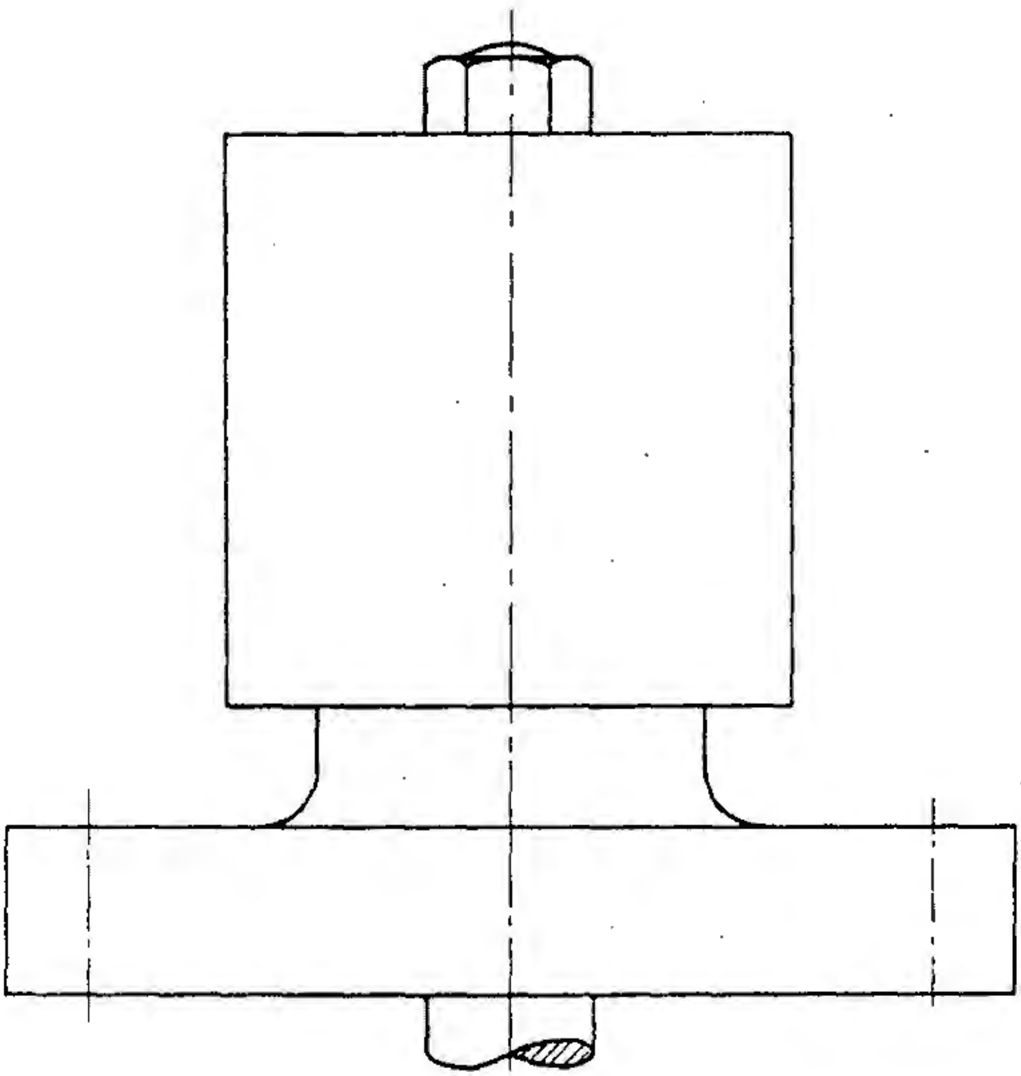


DIAGRAM SHEET 2
DIAGRAMVEL 2