

THE IDENTIFICATION OF COMPETENT ARTISANS  
UNDER THE PRESENT STATUTORY SYSTEM

by

John Basson - B Comm H B A

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## OPSOMMING

Wanneer ons deesdae enige artikel omtrent die algemene fabriekswese in Suid Afrika lees, is daar feitlik sonder uitsondering sprake van die algemene tekort aan geskoolde arbeid.

Alhoewel die Suid Afrikaanse ekonomie tans 'n fase van laaghoujunktuur beleef, bly die vraag na tegniesgeskoolde arbeid op verskeie vlakke redelik hoog - die stelling word daagliks deur die poste-advertensie in Suid Afrikaanse nuusblaai bevestig.

Alhoewel daar meningsverskil omtrent die tydsfaktor is, weet ons almal dat die Suid Afrikaanse ekonomie een of ander tyd weer 'n opswaai gaan beleef. As ons nou reeds met 'n groot tekort aan behoorlik opgeleide mense sit, wat gaan ons probleem wees indien die ekonomie wel gaan opswaai?

Waarom het ons die probleme? Was dit swak beplanning in die verlede, of is daar ander faktore wat meegehelp het, en nog steeds die oorsaak is dat ons met 'n tekort aan geskoolde arbeid sit?

Ons sal maar die verlede vergeet en 'n paar probleme noem wat by meeste nyweraars redelik bekend is. Van die belangrikste probleme is:

- Ons het vandag in Suid Afrika 'n groot verskeidenheid van kulture en 'n groot verskil in die vlakke van algemene opvoeding en opleiding, veral tussen Blank en Swart.
- Alhoewel die Swartes die grootste komponent van die bevolking uitmaak, is 'n groot persentasie van hulle vandag nog steeds ongeletterd of het 'n lae vlak van skolastiese opleiding. Voordat mens met enige geskoolde opleiding kan begin, is 'n sekere minimum vlak van opvoeding noodsaaklik. Hierdie faktor alleen diskwalifiseer 'n groot persentasie Swartes alreeds van die begin af.
- As gevolg van die geslote geleedere - ooreenkoms ("closed shop") met sekere vakunies, word Swartes in sekere kategorië geskoolde arbeid, nie toegelaat om lid van daardie vakunie te word nie en word dus gevolglik van die opleiding en indiensneming in sekere bedrywe uitgesluit.

- Statutêre Reëlings:

Alhoewel daar reeds baie verandering in onlangse wetgewing aangebring is om diskriminerende praktyke uit te skakel, is daar nog steeds wetgewing wat sekere persone wat nie as "geskeduleerde" persone geklassifiseer is nie, uitskakel. Dit sluit op die oomblik sekere Swartes uit.

- Die twee jaar verpligte militêre oproepstelsel, het 'n groot getal van ons geskoolde mannekrag uit die bedryf getrek en doen dit nog steeds.

Wie is dan die mense wat oorbly om die ekonomie aan die gang te hou?

Hoe identifiseer ons die mees kritieke tegniese vaardighede om te probeer verseker dat ons hulle minstens probeer oplei of in diens neem?

Is daar ander metodes beskikbaar waardeur ons mense kan oplei om die nodige vaardighede te bekom wat so nodig is?

Hierdie en ander probleme word in die skripsie bespreek en na oplossings voor gesoek.

As gevolg van ons snelle verhoging in tegnologie, is dit egter onmoontlik om daaraan te dink om ons standaard van opleiding te verlaag, intendeel die vraag is steeds na hoër standaarde.

Sekere metodes wat in die skrywe bespreek word maak wel voorsiening vir die tipe opleiding wat reeds begin met die korrekte keuse van mense-materiaal deur middel van vroeë keuring en aanlegtoetse.

Al sou alle statutêre - en vakbondbeperkinge egter verwyder word, het ons egter nog steeds 'n groot probleem op die korttermyn en moontlik 'n groter een op die langtermyn.

Ons het net nie voldoende Blankes om opgelei te word om in die vereiste behoeftes te voorsien nie, en soos gegewens in die skrywe ook toon, het ons wel 'n groot bron van Swart arbeid om van gebruik te maak, maar daar is sekere Opvoedkundige probleme voordat ons met die nodige Opleiding kan begin.

## CHAPTER 1

### INTRODUCTION

The basis of the Apprenticeship System in South Africa was promulgated under

"The Apprenticeship Act  
(Act No. 37 of 1944 as amended)  
together with  
Regulations  
of  
The Republic of South Africa"

We will go back 30 years and have a glance of what conditions were at that time. Following are some interesting points from Chamber documents during 1954:

#### 1.1 Apprenticeship Qualifications

- 1.1.1 Minimum age of 18 years and Standard 6 for riggers and ropemen.
- 1.1.2 Minimum age of 15 years and Standard 6 for all other trades.
- 1.1.3 An apprentice must have a certificate of physical fitness in the prescribed form.
- 1.1.4 An apprentice is not required by law to attend any school except as provided for in the Act.

#### 1.2 Duties of Apprentices

The duties of apprentices are:

- 1.2.1 To be suitably clothed.
- 1.2.2 To maintain the tools supplied in good and serviceable condition.
- 1.2.3 To be punctual, industrious and obedient to authority and to comply with the terms of the Contract of Apprenticeship.

1.2.4 To attend the prescribed technical classes up to at least NTC II and to apply himself diligently to his studies.

1.2.5 To carry out the compulsory military training when called up.

### 1.3 Period of Apprenticeship

The normal period of his apprenticeship was 5 years.

### 1.4 Military Training

He could be called up for military training for a maximum period of 6 months. He was required to make up 3 of the six months of this, in other words he was effectively exempted from 3 months for his military training.

Very few apprentices were however called up for this training, so the majority of apprentices completed their training after 5 years by effluxion of time because there were no trade tests as yet.

### 1.5 Method of Selection on Engagement of Apprentices

The Gold Producers Committee recommended that the following arrangements should be observed when apprentices are engaged on the mines. "At the time of engagement apprentices, together with their parents or guardian should be interviewed by the Resident Engineer or by an official of the rank of at least Section Engineer in order that both the apprentice and his parents or guardian should be made aware of the responsibilities and obligation imposed on apprentices by the signing of indentures and in other matters relevant to apprenticeship".

A few years later the apprenticeship period was still 5 years with a 3 months remission for 9 months military service done during apprenticeship and a further 3 camps of 1 month duration each with full remission, with a compulsory trade test after 5 years.

From evidence discussed later on, the failure rate was about 90% but this made no difference because apprentices still completed their apprenticeship after 5 years by effluxion of time.

In the later 1980's, the military service was extended to 1 year with 4 months remission and the number of camps increased to 5 with a duration of 1 month each and the compulsory trade test at the completion of 4 years of apprenticeship.

Apprenticeship training on the mines was immediately affected on the above change, although apprentices attending the Training Centre at that time still had ample time to do the training.

In the mean time, higher skills were beginning to become necessary due to the fast changing technology and this was looked at by the Government. This gave birth to the concept of the Technicon as an addition to the known concept of Technical Colleges.

Technicians could be trained at these Technicons to a much higher level of skill than previously offered by the Technical Colleges.

A very comprehensive and detailed report was issued on the need for more technical education by Van Zyl, principal of the Pretoria Technical College. We refer to his publication "Meer Tegniese Onderwys-bydrae tot die oplossing van ons Mannekrageprobleem". (Van Zyl, 1965).

The basic problem of the training in the technical field for the country on the long run was identified and certain proposals made by Van Zyl. However, there were still some unresolved problems with the traditional type of training in the technical field, despite certain changes that took place.

In 1972 the mines started sending selected apprentices to the newly found Technicons giving them an opportunity of doing T1 - T4 during their apprenticeship which gave them entry to be selected as Junior Engineers on completion of their apprenticeship.

The time period changed again with the introduction of 2 years military training and an apprentice was now entitled to 8 months remission off his apprenticeship period, but the apprenticeship course also changed to a 3 year compulsory trade test and 3 months military training call up period.

All of a sudden we were in a crisis situation which quickly happened over a period of less than 10 years in more than one way. As was seen in 1954, the apprenticeship was for all practical purposes a full five years as trade tests could only be written after 5 years. Schooling was only compulsory up to a NTC II and technical classes were either one day per week or in the evenings.

Selection was on an ad hoc basis and by means of simple interviews. 10 Years later the apprenticeship could be reduced by 1 year to 4 years due to the allowance of trade tests to be written after 4 years, and although the failure rate was still very high, some managed to pass. No major problems were experienced with the competency of the end product.

The next 10 years brought a dramatic change. The apprenticeship could now effectively be reduced by 2 years to a total time of 3 years before a trade test was allowed.

A much stricter selection system was already introduced in the initial selection and aptitude testing of apprentices, because much more emphasis had since been placed on a higher level of theoretical training due to a higher industry demand for that sort of training. The "block" system of technical education, either at College or Technicon was introduced which allowed much less time for practical training.

A very large emphasis was placed on apprentices passing their trade tests and a lot of time and effort was spent on the training for just that. However, a miserable failing rate of  $\pm 80\%$  was still encountered. But even worse problems arose for those youngsters that managed to pass the trade test after 3 years.

For one, he did not spend long enough as an apprentice to reach a T4 which was the minimum entry qualification as a Junior Engineer. Further on, although he was a qualified artisan in terms of the law, he was deemed INCOMPETENT by line due to a lack of:

- Sufficient practical training and
- Experience.

He spent a lot of time in preparation for his trade test, as will be indicated later, and much of this time spent was a waste of time because it was not relevant to his job he had to do once "out of his time".

This problem was clearly identified by Steyn in his M.A. Thesis "'n Evaluasie van Praktiese Opleiding van Vakleerlinge in Suid-Afrika met besondere verwysing na Passers in die Goudmyn-bedryf". (Steyn, 1976).

This script was published in 1976 and because of the clear and correct identification of the real problem at the time, as well as the relevant proposals for the correction of this dilemma, the mining industry owes a lot of gratitude to this man for this publication.

Steyn advocated a complete new approach to the complete system of training apprentices, not only as qualified, but as competent artisans.

This concept will be discussed in more detail to indicate how our company has largely managed to overcome the main problems experienced with the training of not only apprentices but also older qualified artisans to a level of competency which would not have been possible with the conventional or traditional methods, in the same period of time.

The further development of this system is also considered to have potential for a major contribution of the skilled manpower shortage of the country in general, because by using the modular concept as introduced, one could select out of a prepared system, any combination at any level for your own needs.

In the chapters to follow, we will discuss:

- The Theory behind this new concept
- The System designed out of this Theory
- The Modular System based on the Criteria Reference Instruction System and finally
- The practical application of this Modular System in identifying the competent artisan by means of a measurable and controlled system with practically unlimited potential for those who want to learn for mastery.

The theory behind this new system forms the basis of Learning by Objectives and is more based on individual training. Leading Specialists in this field were Carrol, 1963, Bloom with his publication in 1971, Davies in the U.K. also in 1971 and 1976 and Mager in the U.S.A. in 1975.

#### 1.6 THE TRADITIONAL METHOD

Each traditional teacher begins a new term or course with the expectation that about a third of his students will adequately learn what he has to teach. He expects about one third to fail or to just get by. Finally he expects another third to learn a good deal of what he has to teach, but not enough to be regarded as good students. This set of expectations supported by school policies and practices in grading is transmitted to the students through the grading procedures and through the methods and material of instruction. The system creates a self-fulfilling prophecy such that the final sorting of students through the grading process becomes approximately equivalent to the original expectations.

This set of expectations which fixes the academic goals of teachers and students, is the most wasteful and destructive aspect of the present education system. It reduces the aspirations of both teacher and students, it reduces motivation for learning in students and it systematically destroys the ego and self concept of a sizable group of the students who are legally required to attend school for ten to twelve years under conditions which are frustrating and humiliating, year after year.

Most of the students (perhaps more than 90%) can master what we have to teach them and it is the task of instruction to find the means which enable them to master the subject under consideration. A basic task is to determine what we mean by "Mastery of the Subject" and to search for the methods and materials which will enable the largest proportion of our students to attain such mastery.

Whatever might have been the case previously, highly developed nations must seek to find ways to increase the proportion of the age groups that can successfully complete both secondary and higher education. In our case even primary education on Blacks is an important factor.

The basic problem is to determine how the largest proportion of the age group can learn effectively the skills and subject matter recorded as essential for their own development in a complex society.

However, given another set of philosophic and psychological presuppositions we may express our concern over the consequences for intellect and personality of a lack of clear success in the learning tasks of the school. Learning throughout life will become necessary for an increasing larger segment of the work force. If school learning is regarded as frustrating and even impossible by a sizable portion of the students, then little can be done at later levels to kindle a genuine interest in further learning. School learning must be successful and rewarding as one basis for ensuring that learning can continue throughout life as needed.

There is little question that the schools now do provide successful learning experience for some students - perhaps as many as one third. If the schools are to provide successful and satisfactory learning experiences for at least 90% of the students major changes must take place in the attitudes of students, teachers and administrators as in teaching strategies and the role of evaluation.

As Educators we have used the normal curve in grading for so long as we have come to believe in it. Achievement measures are designed to detect differences among our learners - even if the differences are trivial in terms of the subject matter. We then distribute our grades in a normal fashion. In any group of students we expect to have some small percentage receive A grades. We are surprised when the figure differs greatly from about 10%. We are also prepared to fail an equal proportion of students. Quite frequently this failure is determined by the rank order of the students in the group rather than by their failure to grasp the essential ideas of the course. Thus we have become accustomed to classifying students in about five levels of performance and assigning grades in some relative fashion. It matters not that the failures of one year performed at about the same level as the C students of another year, nor does it matter that the A students of one school do about as well as the F students of another.

Having become "conditional" to the normal distribution we set grade policies in these terms and are horrified when some teacher attempts to recommend a very different distribution of marks. Administrators are constantly on the alert to control teachers who are "too easy" or "too hard" in their grading. A teacher whose grade distribution is normal will avoid difficulties with administrators. But even more important, we effectively convince students that they can only do C or D work by our grading system and even by our system of quizzes and progress testing. Finally we proceed with our teaching as though only the minority of our students should be able to learn what we have to teach.

There is nothing sacred about the normal curve. It is the distribution most appropriate to chance and random activity. Education is a purposeful activity and we seek to have the students learn what we have to teach. If we are effective in our instruction the distribution of achievement should be very different from the normal curve. In fact we may even insist that our educational efforts have been unsuccessful to the extent that the distribution of achievement approximates the normal distribution curve.

Individual differences in learners are facts that can be demonstrated in many ways. That students vary in many ways can never be forgotten.

The actions that these variations must shape having standards and achievement criteria, is a reflection more of our policies and practices than real differences in each case. The basic task in education is to find strategies that will take individual differences into consideration but which differ in such a way as to promote the fullest development of the individual.

A learning strategy for mastery may be derived from the work of Carrol (1963). Our main concern is with the major variables in a model of school learning and the ways in which the variables may be utilized in a strategy for Mastery Learning.

Put in its briefest form, the model proposed by Carrol (1963) makes it clear that if the students are normally distributed with respect to Aptitude for some subject (mathematics, science, literature or history, for example), and all the students are provided with exactly the same Instructor, the end result will be a normal distribution curve on an appropriate measure of achievement. Furthermore, the relation between achievement and aptitude will be fairly high (a correlation of  $\pm 0,70$  or higher is to be expected if the aptitude and achievement measures are valid and reliable.)

Conversely if the students are normally distributed with respect to aptitude but the kind and quality of instruction and the amount of time available for learning are made appropriate to the characteristics and needs of each student, the majority of students may be expected to achieve mastery of the subject. And in relation between aptitude and achievement should approach zero. It is the basic set of Ideas we want to develop in the following discussion.

This is considered to be the five variables in learning:

1.7.1 Aptitude for particular Kinds of Learning

Teachers have come to recognise that individuals do differ in their aptitudes for particular kinds of learning, and over years, test makers have developed a large number of instruments to measure these differences. In study after study, it has been found that Aptitude Tests are relatively good predictors of achievement criteria (achievement tests or teacher judgements). Thus for example a good set of mathematics aptitude tests given at the beginning of a course in algebra will bear a correlation of as high as  $\pm .70$  with the achievement tests given at the end of the year.

The use of aptitude tests for predictive purposes and the high correlations between such tests and achievement criteria have led many of us to the view that high levels of achievement are possible only for the most able students. From this it is an easy step to some notion of a casual connection between Aptitude and Achievement. The simplest notion of casualty is that the students with high levels of aptitude can learn the complex ideas of the subject, whilst the students with low levels of aptitude can learn only the simplest ideas of the subject.

Quite in contrast with this is Carrol's view that Aptitude is the amount of time required by the learner to attain mastery of a learning task. Implicit in this formulation is the assumption that given enough time, all students can conceivably attain mastery of a learning task. If Carrol is right, then learning to mastery is theoretically available to all, if we can find the means for helping each student. This formulation of Carrol's has the most fundamental implications for education.

One type of support for this view is to be found in the grade of norms for many standardised achievement tests.

1.7.1.1 These norms demonstrate that selected criterion scores achieved by the top students at one grade level are achieved by the majority of students at a later grade level.

1.7.1.2 Further support is provided by studies of students who are allowed to learn at their own rate. These show that although most students eventually reach mastery of each learning task, some achieve it sooner than do others.

Can all students learn a subject equally well? That is, can all master a learning task at a high level of complexity? From a study of aptitude distribution in relation to student performance we have become convinced that there are differences between the learners at the extremes and the remainder of the population. At the top of the aptitude distribution (the upper 1% to 5%) there are likely to be some students who have an unusual talent for the subject. These are able to learn and use subject with greater fluency than others. The students with special aptitudes for music or foreign languages can learn these subjects in ways not available to most other people.

Whether this is a matter of native endowment or the effect of previous training is not clear, although this must vary from subject to subject. It is likely that some people are born with sensory organs better to sound, music or language than others and that these constitutional characteristics give them special advantages in learning the related subjects. For other areas of study, such factors as special training and particular interests may develop these high level aptitudes.

At the other extreme of the aptitude distribution, there are students with special disabilities for particular kinds of learning. The tone-deaf will have great difficulty learning music, the colour-blind will have special problems in learning art, and the individual who thinks in concrete forms will be at a disadvantage in learning systems as a philosophy.

Again it is believed that these constitute less than 5% of the distribution but this will vary with the subject and the aptitudes.

In between are approximately 90% of the learners about whom the writer believes that aptitudes are predictive of rate of learning rather than the level of complexity of learning that is possible. Thus we are expressing the view that, given SUFFICIENT TIME and APPROPRIATE types of help, + 95% of students (the top 5% + the next 90%) can learn a subject with a high degree of mastery. To say it in another way, we are convinced that the grade A as an index of mastery of a subject, can under appropriate conditions, be achieved up to 95% of the students in the class (It has been demonstrated with C.R.I. that at least 90% of trainees selected for a course, can achieve at least 90% of objectives. We will come to this later).

It is assumed that it will take some students more effort, time, and help to achieve this level than it will others. There will be those for whom the effort and help required may make it prohibitive. Thus to learn high school algebra to a point of mastery may require more than a year for some student but only a fraction of a year for others. Whether mastery learning is worth the great effort the first group must invest is highly problematic. A basic problem for a mastery - learning strategy is to find ways of reducing the amount of TIME the slower students require to a point where it is not prohibitively long.

It is not assumed that aptitude for particular learning tasks is completely stable. There is evidence that aptitudes may be modified by environmental conditions or learning experiences in school and at home. The major task of education programs concerned with learning to learn and general education should be to produce positive changes in the students' basic aptitudes. It is likely that these aptitudes can be most markedly affected during the early years in the home and during the elementary school period. Undoubtedly however, some changes can take place at later points in a learner career.

However, even if marked changes do not occur in the individuals aptitudes, it is highly probable that more effective learning conditions can reduce the amount of time which all students, especially those with a lower aptitude requires to master a subject. It is this problem which must be directly attacked by strategies for MASTERY LEARNING.

#### 1.7.2 Quality of instruction

The schools have usually proceeded on the assumption that there is a standard classroom situation for all students. Typically this has been expressed in the teacher - student ratio of 1:30 with the group instruction as the central means of teaching. There is the expectation that each teacher will present the subject in much the same way as other teachers. The standardisation is however emphasised by the adoption of a textbook which specifies the instructional material to be provided for each class. Closely related to this, the extensive research during the past 50 years which has sought to find the ONE instructional method, material or curriculum program that is best for all students.

Thus, over the years, researchers have fallen into the "educational trap" of specifying quality instruction in terms of good and poor teachers, teaching instructional materials, curriculum - all related to Group Results. They persist in asking such questions as, "What is the best teacher for the group? What is the best method of instruction for the group? What is the best instructional material for the group?"

One may start with the very different assumption that individual students may need very different types and qualities of instruction to achieve mastery. That is, the same content and objectives of instruction may be learned by different students as the result of very different types of instruction. We may define the Quality of Instruction in terms of the degree to which the presentation, explanation and ordering of elements of the task to be learned approach the optimum for a given learner.

Much research is still needed to determine how individual differences in learners can be related to variations in the quality of instruction. There is evidence that some students learn quite well through independent study while others need highly structured teaching - learning situations.

It seems reasonable to expect that some students will need more concrete illustrations and explanations than will others, some will need more examples to get an idea than others, some will need more approval and reinforcements than others, and some may need to have several repetitions of the explanation while others may be able to get it the first time.

We believe that if a student had a very good tutor, most of them would be able to learn a particular subject to a high degree. A point to be stressed is that the quality of instruction should be assessed in terms of its effects on individual learners rather than on random groups of learners. Research may suggest more effective group instruction since it is unlikely that schools will be able to provide instruction of each learner separately.

### 1.73 Ability to understand instruction

In most courses at the high school and college levels, there is a single teacher and a single set of instructional materials. If the students find it easy to understand the teachers communications about the learning and the instructional material, he has little difficulty learning the subject or vice versa. The ability to understand the instruction may be defined as, "The ability of the learner to understand the nature of the task he is to learn and the procedures he is to follow in the learning of the task."

Here is a point where the students abilities interact with the instructional materials and the instructors skill in teaching. For the student in our highly verbal schools, it is likely that the ability to understand instruction is determined primarily by verbal ability and reading comprehension. While it is possible to alter an individuals, verbal ability by appropriate training, there are limits to the amount of change that can be produced. Most change in verbal ability can be produced at the pre-school and elementary school levels, with less change being likely as the student grows older. However, vocabulary and reading skills may be improved to some extent at all age levels even though the utility of this approach diminishes with increasing age. Improvements in verbal proficiency should result in improvements in the learner's ability to understand instruction.

The greatest immediate pay-off in dealing with this ability is likely to come from modifications in instruction to meet the needs of the individual instruction.

Given help and various types of aids, individual teachers can find basically 5 ways of modifying their instructions to fit the differing needs of their students.

1.7.3.1 Group Study

Group study procedures should be available to students as they need it. Experience has shown that small groups meeting regularly to go over points of difficulty in the learning process were most effective specially when the students could help each other.

1.7.3.2 Tutorial Help

The one-to-one relationship between teacher and learner represents the most costly type of help and should be used only where alternative procedures are not effective. However, tutoring should be available to students as they need it.

1.7.3.3 Text Books

These vary in clarity with which they explain a particular ideal or process. The question is "Does the learner understand the book, or does he need help as well?"

1.7.3.4 Workbooks and Programmed Instruction Units

These may be especially helpful to students who can't grasp the ideas or a procedure in the text book form. Some students need the drill and specific tasks which workbooks provide.

#### 1.7.3.5 Audio Visual methods and Academic Games

Some students may learn a particular idea best through concrete illustrations and vivid graphic explanations. As particular students are helped, the goal should be not only to help the student over specific learning difficulties but also to enable him to become more independent in his learnings to help himself identifying the alternative ways comprehending new ideas. While efforts may be made to increase the amount of perseverance in students, it is likely that the manipulation of the instruction and learning materials will be more effective in helping them master a given learning task, regardless of their present level of perseverance. Frequency of reward and evidence of success in learning can increase the students perseverance in a learning situation. As he attains mastery of a given task, his perseverance in a related learning task is likely to increase.

Frequent feedback accompanied by specific help in instruction and material as needed can decrease the time (and perseverance required). Improvement in the quality of instruction (explanations and illustrations) may lessen the amount of persistence necessary for a given learning task.

There seems to be little reason to make learning too difficult that only a small proportion of the students can persevere to mastery. Endurance and unusual perseverance may be appropriate for long distance running; they are not great virtues in their own right. The emphasis should be on learning, not on vague ideas of discipline.

#### 1.7.4 Perseverance

Perseverance is the time a learner is willing to spend in learning. Obviously if a student needs a certain amount of time to master a particular task and he spends less than that amount in active learning, he is not likely to learn that task to the level of mastery.

Perseverance does appear to be related to attitudes toward and interest in learning. There is no doubt that students vary in the amount of perseverance they bring to a specific learning task. However, they appear to approach different learning tasks with different degrees of persistence. The student who gives up quickly in his efforts to learn an academic subject may persevere an unusually long time in learning to repair an automobile or play a musical instrument.

It would appear to us that as a student finds the effort rewarding, he is likely to spend more time on a particular learning task. If on the other hand he is frustrated in his learning, he must in self-defense reduce the amount of time he devotes to it. Though the frustration level of students may vary, we believe that all must sooner or later give up a task if it is too painful for them.

#### 1.7.5 Time allowed for learning

Throughout the world, schools are organised to give group instruction with definite periods of TIME allocated for particular learning tasks. A course in history at the secondary level may be planned for an academic year, another course may be planned for a semester, and the amount of instruction time allocated for a subject like arithmetic for standard 6 may be fixed. Whatever amount of time allowed by the school and the curriculum for particular subjects or learning tasks, it is likely to be too much for some students and not enough for others.

For Carrol, the TIME spent on learning is the key to mastery. His basic assumption is that APTITUDE determines the RATE of Learning, and that most, if not all students can achieve mastery if they devote the amount of time needed to the learning. This implies that the student must be allowed enough time for the learning to take place.

There seems to be little doubt that students with high levels of aptitude are likely to be more efficient in their learning and require less time for it than those with lower levels of aptitude whether most students can be helped to become highly efficient learners in general is a problem for future research. The amount of time students need for a particular kind of learning has not been studied directly. One indication comes from studies of the amount of time they spend on homework. Some students may spend 3 to 4 times as much time on mathematics homework as do others.

Although a lot of work was done in developing the philosophy of the importance of TIME spent on learning as a key to MASTERY by writers such as Bloom (1963 and 1971) and Mager (1968 to 1976), it is generally accepted that the work done by Carroll in 1963 forms the basis of this philosophy.

This philosophy, as developed over the years, will be explained and followed in the rest of this chapter as this forms the basis of this script.

The first known tests done in South Africa to prove the validity of this philosophy were done by Steyn in 1976. These tests will be described at the end of the chapter.

This task of a STRATEGY FOR MASTERY LEARNING is to find ways of altering the time individual students need for learning as well as ways of providing whatever time is needed by each.

## 1.8 ONE STRATEGY FOR MASTERY LEARNING

There are many feasible strategies for mastery learning. Each must incorporate some way of dealing with individual differences in learners by relating the instruction to their needs and characteristics. Each strategy must find some way of dealing with the 5 variables discussed in the foregoing section.

Were it not so costly in human resources the provision of a good tutor for each student might be an ideal strategy. In any case the tutor/student relationship is a useful model to consider when one attempts to work out the details of a less costly strategy. Also the tutor strategy is not so far fetched as it may seem at first glance. In the pre-school period, most of the child's instructions is tutorial - usually provided by the mother. Other strategies include permitting students to go at their own pace, guiding students with respect to courses they should or should not take and establishing different tracks or streams for different groups of learners.

In order to develop mastery learning in students, one must be able to recognise WHEN they have achieved it. Teachers must be able to define what they mean by mastery, and they must be able to collect the necessary evidence to establish whether or not a student has attained it.

The specifications of the objectives and content of instruction is one necessary means of informing both teachers and students of the learning that is expected. The translation of the specifications into evaluation procedures helps define further what it is that the student should be able to do when he has completed the course. The evaluation procedures used to appraise the outcomes of instruction (Summative evaluation) helps the teacher and student know when the instruction has been effective.

Implicit in this way of defining the outcomes and preparing evaluation instruments is a distinction between the teaching - learning process and the evaluation process. At some point in time the results of teaching and learning can be reflected in the evaluation of the students. But these are SEPARATE processes. That is, teaching and learning are intended to prepare the student in an area of learning, while summative evaluation is intended to appraise the extent to which the student has developed in the desired ways. Both the teacher and the learner must have some understanding of what the achievements are and both must be able to secure evidence of progress toward these criteria.

If the achievement criteria are primarily competitive, that is if the student is to be judged in terms of his relative position in the group, then he is likely to seek evidence of his rank in the group as he progresses throughout the learning tasks. It is recognised that competition may be a spur to students who view others in competitive terms but much of learning and development may be destroyed by a primary emphasis on competition. Much more preferable in terms of intrinsic motivation for learning is the SETTING OF STANDARDS of MASTERY and excellence apart from interstudent competition, followed by appropriate efforts to bring as many students to these standards as possible.

This suggests some notion of ABSOLUTE CRITERIA and the use of grades or marks which will reflect them. Thus it is conceivable that all students will achieve mastery and the grade of A. It is also possible in a particular year in a specific course for a few or none of the students to attain mastery or a grade A.

While it would be desirable to use absolute standards carefully worked out for a subject, we recognise the enormous difficulty of arriving at them. The standards must however be such that students must feel that they are being judged in terms of level of performance - rather than on a NORMAL CURVE or some other arbitrary and relative set of standards. What is thus recommended are realistic performance criteria developed for each school or group followed by instruction procedures which will enable the majority of students to attain them.

One result of this method of setting achievement standards will be that it will enable the students to work with and help each other without being concerned about giving special advantages (or disadvantages) to others. Co-operation in learning rather than competition was a clear result from this method of setting achievement criteria. This will be discussed in more detail in chapter 4 of this script when the acceptance of this type of learning will be demonstrated.

## 1.9 OPERATING PROCEDURES

The operating procedures used are intended to provide detailed feedback to teachers and students and to furnish specific supplementary instructional resources as needed. These procedures are divided to ensure MASTERY of each learning unit in such a way as to reduce the TIME required while directly affecting both the quality of the instruction and the students ability to understand the instruction.

### 1.91 Formative Evaluation

One useful operating procedure is TO BREAK A COURSE OR SUBJECT INTO SMALLER UNITS OF LEARNING called MODULES. The unit may correspond with a chapter in a textbook, a well-defined content portion of a course or a particular time unit of the course. Tests should then be run on the selected module to determine the time and effort the selected students should take to master it. Each such formative test must be administered after the completion of the appropriate learning unit.

While the frequency of the progress tests may vary throughout the course it is likely that some portions of the course and especially the early sections may need more formative tests than later ones. Where some of the learning units are basic and thus prerequisite for others, the tests should be administered frequently enough to ensure thorough mastery of the material.

He may be informed by the grading system as well as by the discovery that he can adequately cope with the variety of tasks and the problems in the evaluation instruments.

When the student has mastered a subject and when he receives both objective and subjective indications of this, there are profound changes in his view of himself and of the outer world.

Perhaps the clearest evidence of effective change is the interest the student develops for the subject he has mastered. He begins to like it and to want more of it. This will be discussed in more detail in chapter 4.

To do well in a subject opens up further avenues for exploring it - conversely to do poorly in a subject closes an area to further voluntary study. The student desires some control over his environment and mastery of a subject gives him some feeling of control over a part of his environment. Interest in a subject is both a cause of mastery of the subject and a result of mastery. Motivation for further learning is one of the more important consequences of mastery. Nothing breeds success like success.

For the student who has thoroughly mastered the unit, the formative tests should reinforce the learning and assure him that his present mode of learning and approach to study are adequate. The student who consistently demonstrates mastery on the recurring tests, should be able to reduce his anxiety about his course achievement.

For the student who lacks mastery of the unit the formative tests should reveal the particular points of difficulty - that is, the specific questions he answered incorrectly and the ideas, skills and processes he needs to work on. It is most helpful when the diagnosis shows elements in a learning hierarchy that he has not yet mastered. It has been observed that students respond best to the formative tests results when they are referred to particular instructional materials or processes intended to help them clear up their difficulties. The diagnosis should be accompanied by a very specific presumption if the students are to do anything about it.

Although there is limited evidence on this point, we are of the opinion that formative tests should not be assigned grades or quality tests. The tests are marked to show MASTERY and NON-MASTERY.

The non mastery evaluation is accompanied by a detailed diagnosis and prescription of what has still to be done before mastery is complete. It is likely that the use of grades on repeated progress tests prepares students for the acceptance of less than mastery. To be graded C repeatedly for instance, inclines a learner to accept a C as his "fate" for the course, especially when the grades on progress tests are averaged in as part of the final mark. Under such conditions there must come a point when it is impossible to do better than a particular GRADE in the course and there is little value in striving to improve. This is a very important point which will be discussed further in chapters 5 and 6 when we will discuss the grading of artisans.

#### 1.9.2 Alternative Learning Resources

It is one thing to diagnose the specific learning difficulties a student has, and to suggest the steps he should take to overcome them. It is quite another to get him to do anything about it. By itself the frequent use of progress tests can improve achievement to a small degree. If in addition the student can be motivated to expand further effort on correcting his errors, he gains in achievement can be very great.

The most effective procedure found thus far is to have small groups of students two or three as noted above - meet regularly for as long as an hour a week to review the results of their formative evaluation tests and to help each other overcome the difficulties identified on the tests. Tutorial help has been offered as students desired it, but so far those at the secondary or higher education level do not seek this kind of help frequently.

Other types of learning resources that have been prescribed for students include:

1. Rereading particular pages of the original materials;
2. Rereading or studying specific pages in alternative textbooks or other materials;
3. Using specific pages of workbooks or programmed texts and
4. Using selected audiovisual materials.

#### 1.10 OUTCOMES

The traditional teaching system cannot tolerate Mastery Learning because it is based on (confused by) the selection approach which requires a limited proportion of candidates to score high on a test. With this assumption they have adjusted the grading system so as to certify that only a small percentage of the students, no matter how carefully selected are awarded a grade A. If a group of students learn a subject better than a previous group, teachers persist in awarding the A to only the top 10 to 15%. They grudgingly award grades of D and C to the majority of students whom they merely see as having "gotten by". Mastery and recognition of mastery under the present relative grading system is unattainable for the majority - but this is the result of the way the education system is designed.

Mastery must be both a subjective recognition by the student of his competence and a public recognition by the school or society. The public recognition must be in the form of appropriate certification by the teacher or the school. If this is denied him, then no matter how much he has learned the student must come to believe that he is inadequate rather than the system of grading or the instruction. Subjectively the student needs to gain a feeling of control over ideas and skills. He must come to recognise that he "knows" and can do what the subject requires.

If the system of formative evaluation and summative evaluation informs the student of his mastery of the subject he will come to believe in his own competence.

## 1.11 SYSTEMS DESIGN FOR LEARNING FOR MASTERY APPROACH

We have so far criticized the conventional training system and also advocated a new concept. But how can this new proposed system be applied in practise? What would a system like this look like to be able to meet the criteria set?

This system can be termed CRITERIA Referenced Instruction (C.R.I.) which is a competency based instruction system, as opposed to the traditional instruction system with its chanced based approach.

We will now firstly describe this C.R.I. system in more detail and then demonstrate the difference of using the two systems in the training of apprentices and the difference in results achieved.

### 1.11.1 Characteristics

As its name implies C.R.I. is instruction designed to ensure that the learner attains the level of performance (Criteria) specified in performance objectives.

Implicit in this is an assumption that practically all qualified students will be able to attain the criterion. Theoretically all qualified students should be able to attain competence. In reality, some students may not be able to perform within time or other limitations imposed by the system.

Any system in which student performance is judged by explicit criteria has to be accepted under this definition of criterion referenced instruction. However, C.R.I. that is well designed and efficient in operation has a number of additional characteristics. A course that has all of these characteristics might be thought of as ideal C.R.I. The characteristics are described below. When we refer in the future to C.R.I. it is the ideal C.R.I. to which we will be referring, unless we specifically state otherwise.

One more note before we get down to business. A number of persons have developed approaches to instruction that are essentially C.R.I. but that have different names, for example Mastery Learning, Individual Instruction, Competency Based Instruction (C.B.I.) Learner Controlled Instruction (L.C.I.) and Learning By Objectives (L.B.O.)

Depending upon who is reporting, these terms tend to have somewhat different meanings. The resources for this unit contain reports on some of what we consider the better examples of these approaches. We will however find that these approaches have most if not all of the desirable characteristics of "ideal C.R.I." Basically then C.R.I. is instruction in which:

- Performance objectives exist for each of increment of the course;
- All tests are based on these objectives, no more, no less;
- A student does not progress to the next increment of instruction until he or she has exhibited competence at the criterion level (or above) in the current assignment.

An efficiently implemented C.R.I. course ("ideal course") would have the following additional characteristics:

- Objectives are made available to the students in writing at the outset;
- Students take criterion tests wherever its reasonable to think they are ready for them (This might happen without instruction from the course where they think they know enough to test themselves);
- Students receive immediate feedback on their test performance;
- Rate of progress is determined by students demonstrated ability. If they can pass a criterion test, they are allowed to go to a next increment of instruction.
- Inadequate performance on a test is not regarded as evidence that the student deserves a low grade. Instead it is seen as evidence that:
  - (1) he or she needs added help to get to the criterion level and
  - (2) the resources may be inadequate on the objective unrealistic.
- As far as possible, each student has freedom in sequencing his or her own instruction;
- As far as possible, students select for themselves the resources on which they are to draw for instruction;
- The Instructor serves as one such resource, wherever possible, rather than as the sole even chief resource of the course.
- The Instructor sees his major role as an "individualiser" of instruction to fit the varying needs of the students, an important function is motivating students.

In addition in a well designed C.R.I. course, you would expect to find the following:

- Objectives derived from the students' ultimate needs;
- Learning resources and experiences selected for their compatibility with the needs and interests of the student population;
- A mechanism for generating feedback to the Instructor and course designer about what works and what does not work in the course so that good features can be perpetuated and bad features eliminated.

When one encounters a course in which these characteristics are present, you can expect to find a number of other things as well:

- Since the students have the objectives there is no "mystique" about what is going on. Students no longer spend time and effort trying to "psych out" the Instructor, they no longer gamble on investing extra time in studying topics that they believe are "bound" to be included in the final;
- Students take different lengths of time to complete the course. In a reversal of the conventional approach, the Amount of Learning has become a constant of the course and TIME has become a variable. Some students will need more time than is conventionally allowed, others will finish in a shorter time than usual;
- Students who complete all of the subjects in less than allocated time will have an opportunity to spend their time doing something they find rewarding - even doing nothing if that is what pleases them;

- There is probably much more interaction between students than is found in the conventional class. Since a student can serve as a resource to another student, students may find themselves in a teaching "role" Since instruction is selfpaced, a student who feels that he has earned a tea break is free to take one. Conversely for a student who wishes to work longer than the assigned period, facilities will be available;
- The Instructor schedules few formal lectures. Soon after the class gets under way, students will be at different places in the course, so that a lecture for all is seldom appropriate;
- The Instructor becomes the prime resource for diagnosing and providing help for the difficulties of individual students;
- The Instructor puts much emphasis on his role as a motivator of students;
- The issue of grading is approached in an entirely different way than is used in a conventional course.

In C.R.I. the student "passes the course" when he can demonstrate the desired competence.

## 1.12 GRADING

Conventional grading system assume that students have varying degrees of competency in the subject matter at the end of a given length of time. The assumption holds up fairly well in a course of FIXED LENGTH, and the distribution of measures of student competency is likely to approximate the bell shaped curve of a normal distribution. As a result, many teachers try to devise tests that sample student competence can lead to a "spread of results" using statistical or other techniques, some then identify the ranges of scores corresponding to better grades as the "top 10% get A". Others arbitrarily assign test scores to grades "a score of 90% or better is an A" and so on. These procedures are questionable, to say the least, since they are based on a number of other assumptions that are often ill founded. It is assumed for instance that tests used are random samples of student competency and that the tests truly measure what they are set out to measure. (Bloom 1971 : 56)

But sampling, (i.e. testing for the presence of some skills but not other) loses its merit as a predictor if the student knows ahead of time some or all the areas to be tested. Such testing loses merit too when students answer correctly or incorrectly for the wrong reasons as when wrong answers are due to a badly written test item or even to a misreading of the question. The procedures is even more suspect when the teacher arbitrarily assigns grades to scores obtained in a sampling examination. If he allows a student to leave the course with a score of say 60% this says that 40% of the course is not important.

Yet, another feature of the conventional approach is the final grade, which incorporates grades earned during examinations (mid-term tests for example) or from assignments completed during the course. The assumption here is that this earlier performance predicts competence (or its lack) yet any absence of competence in a realistic mid course examination is evidence only that the student needs help or practise before being allowed to go on.

When a course is "graded on the curve" the effect is to compare each students' performance with that of his class mate. It tells little about what the individual student can actually do. Its entirely possible that an A grade in a low achieving class is no better than a C in a high achieving class. The moral of the students seems to be that if they want to get good grades in this so called norm referenced system, they must be sure to enroll in a class of dumdums.

A criteria referenced system by contrast does not rely on supposed "random sampling" of student competence. If the course objectives calls for a particular competence, the student has to exhibit that competence. Inability to perform on a test is seen as a signal for more help, rather than an excuse for labelling an individual as inadequate. Success is used as a key to unlock the next learning experience.

A good example may help to show the difference between a norm referenced approach to instruction and a criterion referenced approach.

Suppose you are teaching a group of students how to make coffee. You have broken down coffee making into ten steps:

1. Dissassemble coffee maker;
2. Clean coffee maker;
3. Reassemble coffee maker;
4. Put correct amount of water into pot;
5. Put correct amount of coffee into pot;
6. Percolate  
etc.

The final test consists of coffee making. In this test Tom does everything correct except that he forgets to put in the coffee. In a norm referenced approach, if each step in the procedure is worth 10 points, then Tom would score 90% in his final test. If say two other students in a class of thirty also make one mistake (not necessarily the same one) and everybody else makes more, then Tom also will probably get and "A" grade, since his performance is in the top 10% of his class - even though he failed to make coffee.

In the criterion referenced approach, the terminal objective would say in essence "Make Coffee". At making coffee Tom, as evidenced by results is, "other than competent". He probably needs more practice so that he does not forget any of the vital steps. When he thinks he's ready he will be able to take the test again and as before his competence will be judged on whether or not he makes coffee to some acceptable criterion. (Mager and Pipe 1979)

One might think we have distorted something to pick a simple task in which failure of this kind "could never happen".

At this stage two remarks could be made:

- 1.12.1 Perhaps it would be a simple task for your class but it would not be for a class of students who are mentally or physically handicapped;
- 1.12.2 The same idea holds true for more complicated tasks - repairing an electronic circuit, removing an appendix, preparing a balance sheet etc. In fact, the more complex the task and the more important that it be done right, the more important it is that achievement be appraised by a CRITERION referenced system.

When a school system is making the transition from the conventional approach to the criterion referenced instruction, the issue of insisting that a student must exhibit competence before graduating can conflict with grading policy.

Sometimes for example, policy does not permit teachers to give high grades to a large proportion of their students. Perhaps policy dictates that they cannot use a grading system other than "A" through "F". Or again, the conflict can arise from the teachers views rather than from policy as when a teacher takes pride in his reputation of being a "hard grader" who rarely awards top level grade.

To apply such policies or views in criterion referenced instruction is to miss the whole point of course. Ideally at any given moment, while he is in a C.R.I. course, a student is either competent or not yet competent with respect to any given objective.

### 1.13 HISTORY AND EFFECTS OF TRADITIONAL MALPRACTISES ON APPRENTICESHIP SYSTEM

Although the Department of Labour (now Department Manpower) was administering the Apprenticeship Act and the Dept of National Education was responsible for the Trade Testing of apprentices at the Central Organisation for Trade Testing (C.O.T.T.) industry was primarily responsible for improving its own apprenticeship system.

In spite of some important improvements since 1954 and about 1974 when the trade tests were introduced for already more than 15 years more than half the countries 40,000 apprentices were still failing their trade tests. The training period for apprentices then varied from 3 to 5 years. The nominal rate for an apprentice was then about R200 per month and for approximately 40,000 apprentices the system was costing the country in the region of  $\pm$  R100 m per annum with a cost effectiveness index of course efficiency based on 50% (learner success) the wastage could be R50 m per year. (Steyn 1980).

Even if the systems wastage was not determined in financial terms, this still reflected a manpower wastage in terms of under utilisation of demotivation and demoralisation of apprentices and staff concerned with their training and testing.

This situation was thus faced by thousands of apprentices in some major trades, including Fitters, Electricians and Boilermakers. With regard to learning success it was the problems with all those who failed the trade tests and who were told that they were "dropouts" because of their inability to pass the compulsory trade test at the end of the years of study and experience (which was shown by Steyn, had been allowed to range between the extremes of course effectiveness) Yet they were allowed to qualify as artisans by effluxion of time, i.e. chance learning.

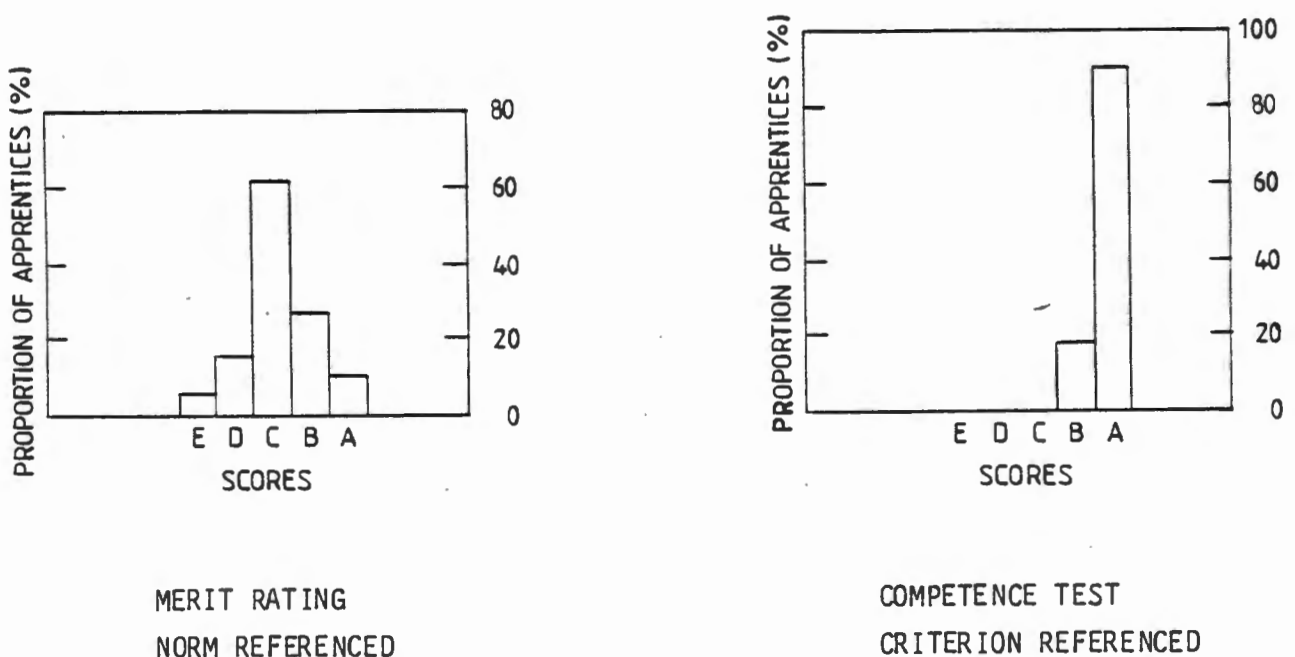
In his endeavours to find out why the trade test failing rate for apprentices remained so high, despite a lot of effort from industry to try and reduce this, Steyn indentified the problem as a lack of a built-in objective-based control system in allowing the major outputs of the apprenticeship system to vary at random. He then did some very interesting tests in his groups' apprentice training centre in applying the principles of C.R.I. which he called Learning by Objectives L.B.O. The results of the tests which includes some graphs, are now following.

The tests were over a period of 3 years from 1974 to 1976. The emphasis was on improving course efficiency while more typical job related equipment was brought into the training centre to improve course effectiveness.

A report was drawn up referring to the internal competency test results obtained not to the national trade test results.

Before his LBO system was introduced the Centres' internal test results were normally distributed around grade C, similar to the merit rating results for apprentices.

Fig. A Results of Apprentices N = 298 in Merit Rating and Competence Tests (Steyn 1976)



In 1976 the centres' training centre was then largely based on LBO except for certain tests.

Fig A shows the total results of the centre for 1976 comparing the two different distributions obtained by the same apprentices in merit rating and competency tests.

The competency tests results of 92 first year apprentices in 1977 was 98% obtained an "A" and 2% a "B" symbol while they obtained an average merit rating score of 63.

The results emphasised the fact that norm and criterion referenced measures are two TOTALLY DIFFERENT TEST dimensions or reference standards.

The absence of criterion referenced performance standards in the past created the false impression that competency was also a normally distributed human characteristic which could be "graded on the curve" like merit ratings.

In fact, this traditional confusion of competence with individual differences in test criterion is largely due to the inability of trainers and psychologists to define competence in absolute measurable performance terms. The results above are evidence of an efficient learning situation resulting from criterion referenced course validation.

Implications of L.B.O. or C.R.I. This concept as the central theme of present day instructional technology is already an accepted part of a promising norm in the training world. It has proved itself as a powerful training system for the achievement of new learning objectives at any level in the organisation with a positive influence on the attitude of the learners.

It has already proven to reduce training periods and costs drastically because of its positive effects on trainees and trainers it meets with a high level of acceptability where it was implemented effectively.

In the chapter to follow the successful application of the principles discussed so far by means of (1) proper selection of human material and (2) controlled application of the C.R.I. principles on a modular basis will be discussed in more detail.

## CHAPTER 2

### SELECTION CRITERIA HISTORY OF SELECTION METHODS, CURRENT SYSTEMS IN USE AND RESULTS OBTAINED

The advancement of technology sets an increased demand on the abilities and capabilities of those people that have to design, manufacture and maintain equipment.

We thus have to cater and plan in two ways:

- Retrain our existing artisans to keep up with the change.
- Select and train our new employees to reach the level of competency required for the job.

Retraining of existing artisans will be dealt with later on. We will now concentrate on the selection and employment of new recruits for training.

#### Old Method

As was seen in chapter one, the method of selection and employment of an apprentice 30 years ago was very crude and unprofessional.

A birth certificate to prove his minimum required age of 16, a school certificate to prove that he had no further formal schooling obligations and a short interview of a line official to the level of a section engineer and his parents were all that was required.

However, things have vastly changed over the years and today we have far superior methods of selection.

This is also very essential, because the demand on the level of skill and competency placed on the competent artisan is of such a high standard that only certain selected individuals are able to meet that standard.

You can only build or manufacture certain products if you have the correct material and great care must be taken to ensure the correct quality at an early stage, in a production sense.

In the human sense it is even more important because it costs a company in the region of R30 000 to R40 000 to train an apprentice today.

Over the years various tests and selection methods have thus been developed to try and ensure that the selection of the different trade requirements are done in such a way that the necessary skills and abilities are present to enable the apprentice to meet the laid down criteria for his trade.

Selection can only be done if you have sufficient numbers to select from. Otherwise one can only place applicants to the best of your ability if you have not got enough material to select from.

The first step in this selection programme is however that by means of a Manpower Planning Programme one must decide how many of each trade is required to be employed so that in the long run, you will have trained sufficient men to meet your demands. This planning is done on a corporate basis, planning for the number of intakes required per year, also ensuring that you have sufficient trainees and training facilities to control your training needs.

This chapter will be divided up as follows:

- (1) Description of selection methods, i.e. aptitude testing and interviews.
- (2) Validation: Checking up the relationship between the aptitude test results and success in training by means of the ultimate trade test results.
- (3) Comparison between the different selection methods used later on, that is, Intermediate Battery and Otis battery test which was only introduced in 1980 as an additional measurement.
- (4) Results so far on fairness of aptitude test battery scores on difference race groups since the indentoring of Non White apprentices on chamber mines.

## 2.1 SELECTION METHODS

### 2.1.1 Aptitude testing

There are two prerequisites for skill: aptitude which is a gift from God, and experience. Of these, aptitude is by far the most important. We might define it as the capacity to derive skill from experience. In some cases aptitudes have remained latent and unrecognised for centuries, simply because the occasion never arose that demanded them.

It is however only one part you look at when you decide whether to engage a person for your company.

We do not claim that the aptitude test would give you the total answer. Only a persons potential can be indicated. We can say a person is above average in terms of potential. This does not mean that he is going to make the grade and he may still be a dropout. An interview is also held with him to try and establish his motivation. There could be other problems or potential in his make up that we do not know about. Part of the selection process required is a thorough interview.

There will thus have to be reference checks and other things done to ensure proper and thorough selection. One should thus consider his test results as a part of a data base which you can build up about a candidate. He could for instance have a criminal record which would obviously eliminate him as a potential candidate.

We will firstly concentrate on what is considered as essential aspects of a well organised aptitude test as far as control, methods and procedures are concerned, and then discuss the different types of aptitude tests being applied in our Group.

A certificate of physical fitness which includes a hearing and eye-sight test is required before the selection is started. Results of these tests are factual measurements. These will not be discussed as part of the selection criteria but are considered as prerequisites before selection is started. This also includes clearance from the Medical Bureau in terms of pneumoconiosis as artisan work on the gold mines are considered as "dusty" occupation.

Aptitude testing forms an integral part of any well co-ordinated occupational classification procedure and the general purpose of such testing is to select, classify and place employees in those work categories for which they are psychologically best equipped.

Provided that certain other operational factors which effect the utilization of labour are adequately controlled, aptitude testing has been shown to make a substantial contribution towards the improvements of worker efficiency and hence production. For any labour force, however, a set of conditions which will give an optimum output, can be postulated. In this sense, output level is the resultant of a vast number of factors such as physical working conditions, industrial relations, employer/employee attitudes and ability, training and psychological fitness of the individual workers. The usefulness of selection and classification tests as a means of increasing the efficiency of labour and the raising its output, is therefore materially influenced by the specific set of circumstances particularly those relating to training and labour control, which are operative in the industry or company concerned.

## 21.2 PART A - THE OBJECTIVES OF PSYCHOLOGICAL TESTING IN INDUSTRY

In industry aptitude tests are used for:

1. Selection and
2. Classification.

### 2121 Selection

Here a decision must be made generally to either accept or to reject a candidate. To make this decision, the aptitude test results are utilised in conjunction with an interview. In a selection programme such as the annual intake of apprentices, minimum cut-off points are set on the test battery. Candidates scoring below these points are not accepted. Candidates scoring above the qualifying marks in the tests are interviewed and a final decision taken to accept or reject.

The interview is an informal dynamic testing technique in which test data are checked, queries clarified and an attempt made to assess the personality characteristics of the candidate. The interview situation presents a summing-up procedure on the part of the panel of judges making accept or reject decisions.

#### 2.1.2.2 Classification

In the classification of work-seekers, no candidates are rejected, but each one is classified or categorised on a specific class of work or job group, according to test results. The Classification Test Battery performs a classification function in the gold mines.

### 2.1.3 TYPES OF TEST

In selecting and classifying people for industry, we tend to concern ourselves almost exclusively with the assessment of ability. We construct our tests to measure its principle elements, language, number and perception. We take it that one or other or various combinations of these elements will contribute to occupational success in our Western Technology. Sometime we go further and construct tests designed to select for a specific occupation, e.g. punch card operator, typist. In such cases we attempt to measure scholastic achievement through attainment and interest tests in addition to general ability. But, in all this effort, we assess only a portion of the total effective capacity of a person. His effective capacity is determined, not only by ability, but also by his personality make-up. A person does not work in a vacuum, he has aspiration. He is motivated towards certain goals. He is part of an occupational community, subject to pressure from it.

Our tests are predominantly measures of ability and attainment, e.g. classification test battery, high level battery, (containing tests of mental alertness, language and number manipulation), intermediate battery, normal battery, OTIS. The mechanical comprehension test is basically an attainment test. Over the past few years a new concept in testing was introduced, called Assessment Centres. An Assessment Centre is a formal procedure incorporating group and individual exercises for the identification of dimensions of managerial success identified as important for a particular position or level of management. Ability tests can be more easily constructed and validated. Personality testing is bedevilled by indeterminateness in the concept itself, as well as in the scoring of test material. Validation is a major problem. At present it is easier to isolate items in effective capacity such as leadership and attempt to assess individual effectiveness in a simulated social situation.

#### 2.1.4 STANDARDIZATION

When we give a test to an individual or a group of individuals, our objective is, by putting candidates into an operational situation of some sort, to obtain information on them which will allow us to compare them with others, or to compare them with a standard in order to reach a decision as to whether or not they could be employed, or in what capacity. It follows that the test and the training procedures must be standard, otherwise the comparisons which we make subsequently will be unreliable and invalid, and we defeat our prime object. Human beings are individuals primarily and tend to do things differently from one another. Even the smallest, simplest activities show discrepancies. Hence, since standardization of testing is essential, the need for trained testers is the first requirement. Even with trained testers, standardization is difficult to maintain. There are certain features of standard practice which can be listed and continually checked:-

1. Accommodation (Venue);
2. Preparation of tests and equipment;
3. Preparation of candidates;
4. Language medium;
5. Actual administration;
6. Timing and scoring;
7. Conversion to norms.

#### 2.1.4.1 Accommodation (Venue)

With tests where pattern is available in both official languages, by preference only one language group should be tested in a room on the same test battery, in order to avoid disturbances caused by different test instructions.

Adequate seating arrangements must be available, especially as regards the table space available for each candidate. The room must be free from noises and distractions such as telephones ringing and visitors or late-comers entering and leaving the room. To avoid the latter, a sign should be posted on the door during testing.

Lighting and ventilation must be adequate.

#### 2.1.4.2 Preparation of test equipment

The tester must be familiar with the test instructions for each particular test to avoid stumbling and hesitation while reading instructions.

All materials needed for testing session must be laid out on the tables prior to the testing session to avoid fumbling and searching.

A reliable stop-watch or interval timer must be ready and fully wound. A spare time-keeper should be in stock.

#### 2.1.4.3 Preparation of candidates

Underlying all tests is the assumption that the subject is "doing his best". In the case of White people who are applying for a job, we can assume that they are well motivated. When testing Black people, however, it is necessary to explain the importance of the test and to urge them to work hard and to "do their best".

The element of surprise should be eliminated from the test situation so as to reduce anxiety. The candidate should be properly briefed as to the purpose and duration of the programme. This is to normal testing practice. Where it is not feasible to do this, some substitute familiarisation procedure can be used, such as the buffer test in the Classification Test Battery.

#### 2.1.4.4 Language medium

When administering written tests, candidates must be given the choice of writing the tests in English or Afrikaans. In cases where candidates say they are equally proficient in both languages, the tests should be written in his school language medium. In cases where a foreigner is not proficient in either English or Afrikaans, written tests may not be administered.

#### 2.1.4.5 Actual administration

Test instructions appear to be easy to give, but bad habits can easily be acquired by testers without their being aware of them, and the standard of test administration may deteriorate to a very low level. It is by no means easy to read instructions well. The tester must read instructions slowly and clearly and avoid sounding monotonous and disinterested. An unfavourable attitude or manner on the part of the tester, revealed through the tone of voice, facial expression or lack of expression in reading instructions has been shown to have an unfavourable influence on the candidate's test performance.

The tester must make sure that all candidates are able to hear instructions clearly. It has been found that no matter how efficient a tester is, he is not able to keep his instructions consistent from day to day without set, written instructions. He may tend to lengthen or shorten them then, depending on his mood, perhaps feeling that certain instructions are unnecessary and omitting them completely. But those instructions, set aside light-heartedly by the tester, have been found by the constructor, to be important, relevant and reliable. An omission from the instructions may have serious effect on the candidate's understanding of what is required of him, with the result that his score will suffer accordingly. It is for this reason that instructions must always be read and not be given from memory.

The tester should always be polite and friendly, but at the same time firm. His appearance should be neat and tidy, and his bearing calm and confident. It is not permissible to smoke while giving instructions. The tester should not eat cake, sweets, etc in front of the candidates, as besides being impolite, it creates a bad impression.

During testing, the tester should not look over candidates' shoulders or hover over them with the stop-watch. Nor should they be interrupted with such comments as "You have 10 minutes left", as these factors tend to increase anxiety. No group of candidates may be left unattended, as a candidate may have a query. Also for security reasons it is not permissible to leave a group without supervision. Where possible, candidates should be allowed a few minutes break, if possible a tea break, after they have been sitting for about two hours.

If, in exceptional circumstances, a candidate has to leave the room while he is busy with a test, the amount of time he misses must be noted, and he must be allowed to make up that exact time at the end of the test.

#### 2.1.4.6 Timing and scoring

It is essential that all tests be accurately timed on the intervals given in the test instructions. If the time laid down for the test is not strictly adhered to, the test is no longer standard. Similarly it is essential that the scoring be accurate. Correct items should be counted at least twice.

If a timer is being used, it should be placed so that candidates are not able to see the face of the timer. Candidates should also be warned about the alarm which rings when the time is up.

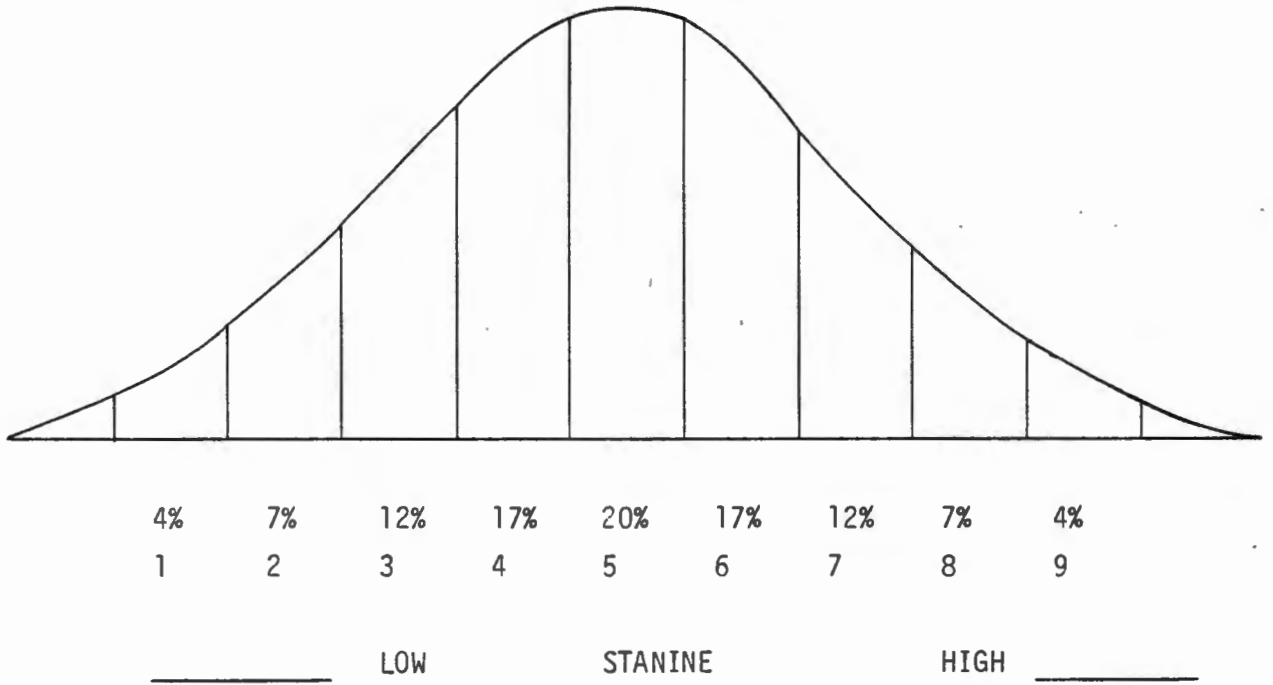
#### 21.4.7 Conversion to norms

The new score obtained from any psychological test has limited meaning. It derives its significance from comparison with the performances of other candidates. To say that a candidate has correctly solved 12 problems in the Computation Test, or indentified 34 words in a vocabulary test conveys little information about his standing in these functions. We therefore interpret these raw scores with the aid of norms. The norms represent the scores that a large representative group of people actually scored in the test. Groups can be representative of various occupational, social or national strata. Hence we construct different sets of norms for the same test. So a score can thus be determined whether his score coincides with the average of the group; or he may be well above average; or in the bottom 2% of the group. By this comparative technique his score becomes meaningful. For convenience, we divide the scale of the normalised standardised distribution into nine equal intervals and call these intervals "stanines". (In the case of the Classification Test Battery the scale is divided into twelve equal intervals called "dudec"). The following diagrams illustrate the normalised, standardised distributions for:

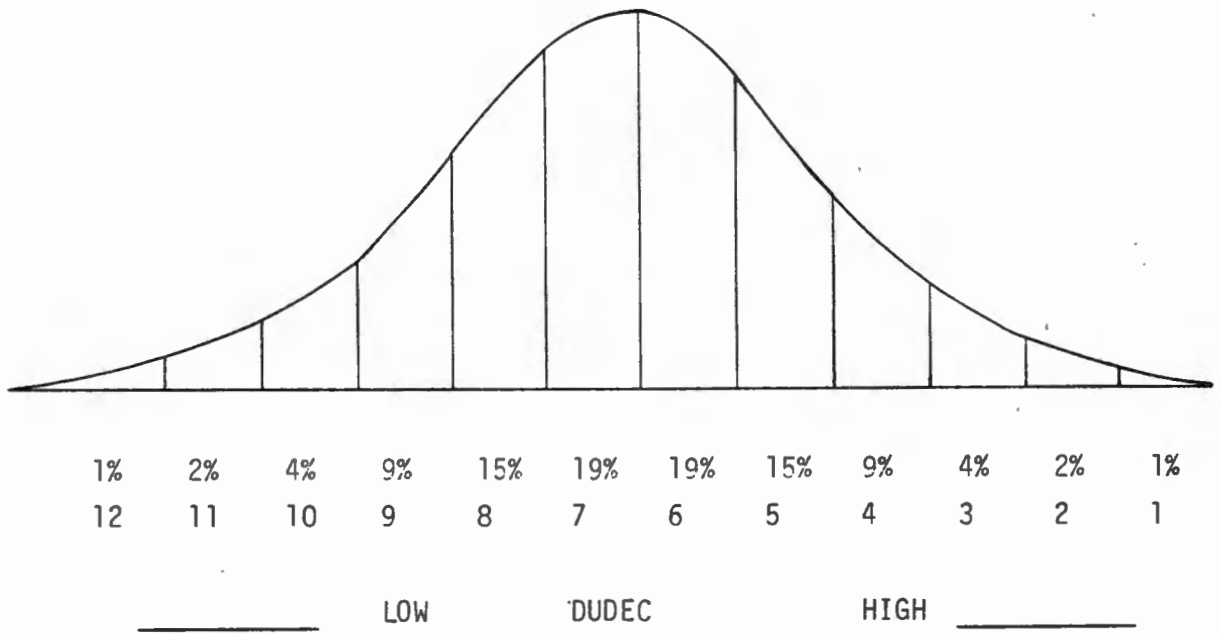
- (1) Stanines,
- (2) dudecs,

and show the percentage of the group falling into each stanine or dudec.

1.



2.



The stanine can be expressed verbally as follows:-

STANINE

1. Very poor	Better than 0 - 4% of the representative group
2. Poor	Better than 4 - 11% of the representative group
3. Well below average	Better than 11 - 23% of the representative group
4. Below average	Better than 23 - 40% of the representative group
5. Average	Better than 40 - 60% of the representative group
6. Above average	Better than 60 - 77% of the representative group
7. Well above average	Better than 77 - 89% of the representative group
8. Good	Better than 89 - 96% of the representative group
9. Very good	Better than 96 - 100% of the representative group

It must be remembered that any norm is restricted to the particular population from which the group, on which that norm was based, was derived. Thus it would be meaningless to convert the raw score obtained by a female clerical applicant on a particular test to a stanine using the norms based on a group of apprentices.

## 2.1.5 USEFULNESS OF TESTS

### 2.1.5.1 Validation

Test validation is the degree to which the test actually measures what it purports to measure. Validation provides a check on how well the test is fulfilling its function. The determination of the validity of a test or battery of tests usually requires an external criteria, i.e. a measurement of the behaviour or performance that we have been trying to predict through the use of the tests. For example, with the battery of tests used for the selection of Learner Officials, one of the main objectives is to predict success, in the technical courses, without which the learner cannot continue. In measuring the validity of the test battery, the amount of agreement or correlation between these scored and results obtained at Technicons is calculated. If the correlation is high, we can predict an applicant's future success on the course with a good measure of certainty. Success cannot, of course, be predicted with 100% certainty.

After a validation study has been carried out, and a battery of tests which do predict a measure of success is established, cut-off points can be laid down.

Candidates scoring below the cut-off points are rejected, candidates scoring above are accepted on their test scores, and the final decision is then made after an interview.

### 2.1.5.2 Reliability

Test reliability is the consistency of scores obtained by the same persons when retested with the identical test, or with an equivalent form of the test. Before a test is released for general use, a thorough check on its reliability must be carried out. A satisfactory degree of reliability has been established on all the tests which are released by the National Institute for Personnel Research.

## 2.1.6 SELECTION AND OCCUPATIONAL RATIOS

### 2.1.6.1 The selection ratio

The selection ratio is defined as the ratio of the number of vacancies over the number of applicants available for selection. A low selection ratio is therefore preferable and this also results in higher efficiency of the tests. A very high selection ratio can serve little purpose, as almost all candidates must be accepted, even if their test scores indicate that they are unsuitable.

### 2.1.6.2 Occupational ratio

Where the selection ratio is unity, we have classification and not selection, i.e. all candidates are accepted, but are classified by test into occupational categories. The occupational ratios are concerned with the supply and demand in the various categories. The supply is the proportion of the test intake that is classified into each occupational category. The demand is the proportion required by the industry in each occupational category. A close relationship must be maintained between the supply and demand ratios.

The following are test selection batteries for our present system. The Otis test battery system was only brought in after 1980 as an additional aide as well as the colour blindness perception test which is relevant to Electricians and Welders where colour perception is important.

#### 2.1.7. APPRENTICE SELECTION BATTERY

The following tests are used for the selection of all apprentices:

2.1.7.1 Intermediate Battery - Mental Alertness  
- Computation

2.1.7.2 Mechanical Comprehension Test

2.1.7.3 Ishihara Colour Blindness Test

2.1.7.4 OTIS Battery

The following are the acceptance levels for apprentices:  
Electrician, Fitter and Turner - Stanine 6 and higher  
Boilermaker - Stanine 5 and higher

A short description will now be given of each of these tests:

#### 2.1.8 INTERMEDIATE BATTERY

The battery consists of 7 multi-choice pencil and paper tests:-

2.1.8.1 Mental Alertness - Test of General Intelligence  
30 questions. Time limit 30  
minutes

- 2.1.8.2 Arithmetical Problems - Test of arithmetical ability  
30 questions. Time limit 45  
minutes
- 2.1.8.3 Computation - Test of computational ability  
30 questions. Time limit 35 minutes
- 2.1.8.4 Spot-the-error - Test of clerical speed and accuracy  
60 items. Time limit 10 minutes
- 2.1.8.5 Reading Comprehension - Test of language ability  
4 paragraphs with 5 questions  
on each paragraph  
Time limit 20 minutes
- 2.1.8.6 Vocabulary - Test of language ability  
30 questions. Time limit 10 minutes
- 2.1.8.7 Spelling Test - Test of language ability  
30 questions. Time limit 15 minutes

The battery is suitable for standards 8 to 10.

2.1.9 MECHANICAL COMPREHENSION TEST

This test is designed to measure technical insight, i.e. the ability to apply knowledge of the laws and principles of physics appropriately.

The test contains 52 multiple choice items in a test booklet. Each item consists of an illustration, a brief clarifying comment (where necessary) and a question with three possible answers, of which only one is correct. The test is suitable for standards 7 - 10 educational levels.

Description

A colour-blindness test, of which the first 21 plates will test for:-

Normal Colour Vision

Red-Green Deficiency

Total Colour-Blindness

21.10.1 Administration

The test must be administered in a room adequately lit by daylight. The introduction of direct sunlight or use of electric light may produce some discrepancy in the results because of an alteration in the appearance of shades of colour. The plates must be held 75 cm from the candidate and tilted so that the plane of the paper is at right angles to the line of vision.

Candidates are asked to call out the numeral which is seen on each plate and each answer should be given without more than three seconds' delay.

2.1.10.2 Scoring

If 17 or more plates are read as indicated in the "normal" column, vision is normal.

If 13 or less plates are read as indicated in the "normal" column, vision is deficient either red-green deficient, or totally colour-blind, depending on answers to plates 2 to 9 and 18 to 21.

It is rare to find a person whose total recording of "normal" responses lies from 14 to 16 plates. These should be listed as doubtful and recommended for further tests.

## 2.1.11 OTIS TEST BATTERY

This battery consists of a general intelligence test with 4 sub-tests measuring various abilities and perceptions.

### 2.1.11.1 Otis

Consists of 75 items with a 30 minutes time limit and measures general intelligence.

### 2.1.11.2 Number series test

Consists of 40 items with 30 minutes to complete the test. It measures a person's ability to determine the relationship between numbers in different series.

### 2.1.11.3 Mechanical knowledge

This test measures a person's knowledge of mechanical devices and consists of 45 items with a 13 minutes time limit.

### 2.1.11.4 Form perception

Measures a person's aptitude in recognising different figures and designs. The test consists of 36 items with a time limit of 15 minutes.

### 2.1.11.5 Space perception

Consists of 40 items with a 15 minutes time limit and measures aptitude in space perception.

## 2.2 VALIDATION

As was mentioned earlier, validation is the degree to which the test actually measures what it proposes to measure.

In our case the object was to measure the potential for a young student to qualify after a certain amount of training as a "competent artisan".

In terms of the Apprenticeship Act the passing of a set trade test after a certain period of time the apprentice qualifies as an artisan - a qualified artisan.

Whether a man is then deemed "competent" is something else.

In terms of the law he is "qualified" and this is one of the main objectives of the normal employer, because once qualified, an Artisan is deemed competent to do certain work and undertake certain legal obligations if appointed.

The successful passing of the Government Trade Test at Olifantsfontein will thus be taken as the norm to measure the relationship and success of the aptitude test versus the trade test results although there has been quite a lot of criticism in the past about method of trade testing and the standards applied. This is the only accepted standard of measurement of the successful completion of the apprentice in terms of a formal recognised test.

The results of trade tests undergone by apprentices between the year 1971 and 1979 will be discussed.

These tests were done by Theron and Barlow-Jones.

The test results at this stage were thus only the results obtained from the Intermediate Battery of the National Institute of Personnel Research.

#### 2.2.1 THE RELATIONSHIP BETWEEN APTITUDE TEST RESULTS AND TRADE TEST RESULTS

The objective of the investigation was to establish to what extent aptitude test results of apprentices can predict the ultimate success of apprentices in the trade test at Olifantsfontein.

Three types of apprentices were used, namely Electricians, Fitters and Turners and Boilermakers. Trade test results of apprentices who have undergone their trade test from 1971 to 1979 were available. Those of which aptitude test results were also available were included in the sample.

At the outset, the idea was to also validate the I.T.B. Test and the Responsibility Test, but not enough cases were available. This will be done in future.

At present certain cut-off scores on aptitude tests are recommended by the Aptitude Test Centre, Welkom for the different trades and an apprentice falling below these cut-off scores is considered not to be a good prospect for apprenticeship training. As a vantage point the present recommended cut-off scores were compared against trade test results.

One of the statistical methods that was used was the efficiency ratio. The efficiency ratio which is expressed in the form of a percentage is derived at by the following formula:-

Efficiency ratio = Number of subjects above a certain cut-off score who passed their trade test the first time plus the number of subjects below a certain cut-off score failing their trade test the first time divided by the total number of subjects times 100.

Unfortunately trade test symbols were not available for many of the subjects but only whether they had passed or failed in their trade test. It was therefore decided to use as criteria whether an apprentice passed or failed his trade test the first time. As there were very few apprentices in the sample who failed their trade test more than once, this seemed to be the most feasible criteria to correlate with aptitude test results.

The results for each trade will now be discussed.

Altogether 40 people (24%) who did not obtain a stanine 6 on all three tests failed the trade test. However, 77 apprentices (47%) who did not obtain a stanine 6 on all three tests did pass the trade test the first time.

The Aptitude Test Centre cut-off score of a stanine 6 on all three tests was therefore correct in the placing of 42 people in the upper right hand block and 40 people in the lower left hand block. The cut-off score was however incorrect in that 6 people in the upper left hand block were supposed to be in the upper right hand block. Altogether 77 people falling in the lower right hand block were supposed to fall in the lower left hand block.

The efficiency ratio of which the formula were given earlier is as follows:-

$$\begin{aligned}\text{Efficiency Ratio} &= \frac{42 + 40}{165} \times \frac{100}{1} \\ &= 49,7\%\end{aligned}$$

The question could be asked whether a cut-off score of 6 on all three tests is in actual fact the best cut-off score available. The mere fact that 117 (40 + 77) apprentices of a total of 165 (i.e. 71%) not scoring a stanine 6 on all three tests were taken on by the mines and the fact that 62% of these apprentices  $\frac{77}{117}$  passed their trade test the first time shows that this cut-off score is unrealistic.

An alternative to this can possibly be to add the stanines together rather than insisting that an apprentice should obtain a stanine 6 on all three tests. The principle followed here in contrast to the preceding approach is that a high score in one test can make up for a low score in another test.

2.2.2 Relationship between aptitude test results and trade test results - Electricians.

The cut-off score recommended by the Aptitude Test Centre for Electricians is a stanine 6 on three aptitude tests of the Intermediate Battery of the National Institute of Personnel Research. These tests are:

- Mental Alertness
- Computation
- Mechanical Comprehension.

The criteria for success was whether a person passed the trade test with his first try. These results were tabulated as follows:-

TABLE 1

Relationship between aptitude test results and trade test results - Electricians

		<u>TRADE TEST RESULTS</u>	
		FAILED	PASSED
Aptitude Test Results	Obtained a stanine 6 on all three tests	6 (4%)	42 (25,5%)
	Did not obtain a stanine 6 on all three tests	40 (24%)	77 (47)%

From the above table it can be seen that the sample of apprentice Electricians used in the study was 165 (6 + 40 + 42 + 77).

Of the 165 apprentices 42 (25,5%) obtained a stanine of 6 on all three tests (Mental Alertness; Computation and Mechanical Comprehension) and also passed the trade test the first time. Only 6 (4%) apprentices with a stanine 6 on all three tests failed the trade test.

The results obtained when adding the stanines obtained in the three tests together and using 18 (18 divided by 3 tests give an average of 6) as a cut-off score gives the following results:-

TABLE 11

Cut-off score of 18 on 3 tests and trade test results

		<u>TRADE TEST RESULTS</u>	
		FAILED	PASSED
Aptitude Test Results	Score of 18 and above	16	79
	Score of 0 - 17	31	39

The efficiency ratio are  $\frac{79 + 31}{165} \times 100$   
 $= 66,6\%$

This is a big improvement compared to the previous efficiency ratio of 49,7% based on a cut-off score of stanine 6 on three tests.

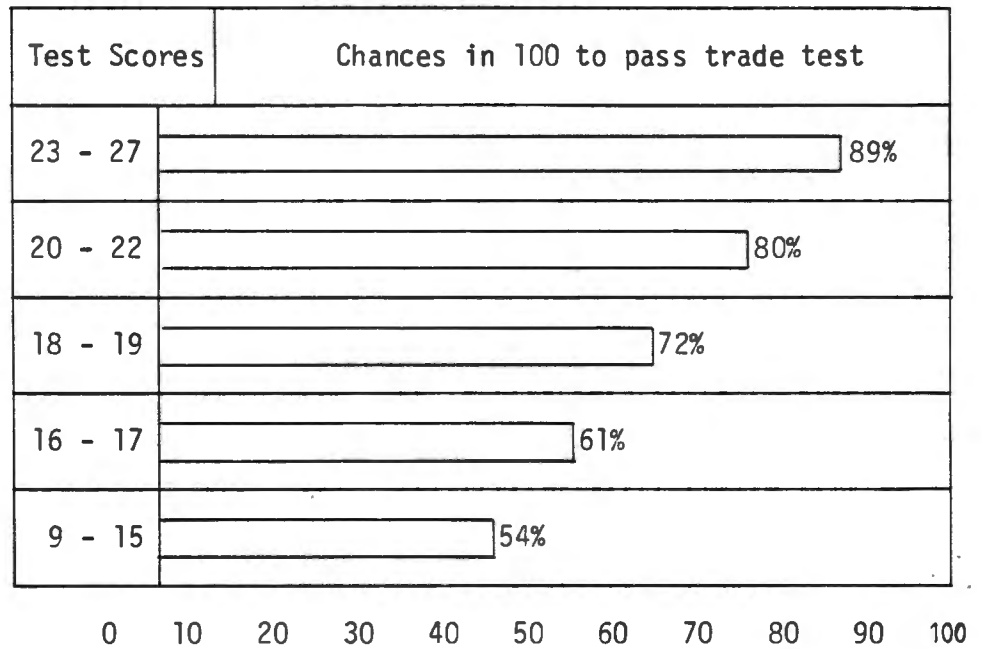
An expectancy chart is necessary if we look at Table 11

From the chart it can be seen that 56% of apprentices who did not obtain a score of 18 on the three tests still passed their trade test the first time. The question can therefore be asked whether some of the better of that 56% cannot be salvaged. This is especially pertinent in view of the shortage of artisans on the mines as was pointed out by the Chamber of Mines (1978).

An expectancy chart was therefore developed to serve as aid in the selection process.

TABLE 111

Expectancy Chart to predict success in the Electrical trade test



The expectancy chart was devised by dividing the subjects into 5 groups. The first group consisted out of the apprentices obtaining the best 20% of test scores (obtain by adding the stanines in three tests together). These scores of the best 20% ranged from 23 - 27. Altogether 89% of apprentices with a score of 23 to 27 passed their trade test first time. Only 54% of apprentices obtaining test scores between 9 and 15 (bottom 20%) passed their trade test first time.

The question could also be asked what the best cut-off score would be. It was found that a cut-off score of 14 (when stanines of the three tests are added together) yielded an efficiency ratio of 74,5%. This is the score where it can be expected that most people taken on with this score would pass and most people not obtaining this score would fail. It is recommended that applicants scoring below 14 not be taken on by the mines. It should, however, be remembered that the cut-off score should be set as high as possible as the higher this score the lower would be the number of failures.

This is of course true in the case of all three apprentices as can be seen from the expectancy charts. Correlations and other statistics were also computed. These are as follows:-

Intercorrelations

Mental Alertness and Computation = ,44 (,1%)  
 Mental Alertness and Mechanical Comprehension = ,38 (,1%)  
 Computation and Mechanical Comprehension = ,23 ( 1%)

Averages

Stanine

Mental Alertness	7	(Raw Score 18,7)
Computation	6	(Raw Score 15,2)
Mech Comprehension	5	(Raw Score 16,2)
Average three tests	18,6	

Correlations between aptitude test results and trade test results

Mental Alertness and Trade Test Results = ,2179 (5%)  
 Computation and Trade Test Results = ,2265 (5%)  
 Mechanical Comprehension and Trade Test Results = ,2279 (5%)  
 Mental Alertness + Computation + Mechanical Comprehension = ,3329 (5%)

The % next to the correlation co-efficient indicates the level of significance of the correlation.

,1% means that there is only 1 in a thousand chance that there is no relationship between the two variables.  
 1% means the chances of no relationship is 1 out of 100  
 5% means 5 out of 100.

As can be seen the correlations of the three tests with trade test results are more or less the same. The correlation of stanines of the three tests added together was, however, higher than any of the individual tests, namely .3329 (.1%). Although the correlations between the tests and trade test were significant, it was relatively low. Prediger, Waple and Nusbaum (1968) computed the average correlation obtained in 10 studies where the results of verbal intelligence tests were correlated with electrical courses at high school level in the U.S.A. The average correlation was .18. The Mental Alertness Test, which can also be classified as a verbal intelligence test, correlated .2179 with trade test results.

The above mentioned authors also found an average correlation in 6 studies of .20 between tests measuring arithmetic and computational ability and electrical courses at school. The Computation Test yielded a correlation of .2265 with trade test results.

Prediger (et al. 1968) did not report the average correlation of tests measuring mechanical insight and knowledge as too few studies reported such correlations. In the present study a correlation of .2279 was obtained. The quoted investigators came to the conclusion that achievement in electrical courses is more difficult to predict than in other technical fields. As will be shown later it was also found that the correlations between aptitude tests for Fitters and Turners and trade test results were higher than for Electricians. It must, however, be stressed that the number of cases in the two groups differ and the correlations are, therefore, not directly comparable. However, the average correlations of aptitude tests against training criteria calculated by Ghiselli and Brown (1951) after a survey of the literature are as follows:-

Electrical Workers:

Arithmetic tests  $r = ,43$ ; intelligence  $r = ,41$ ;  
mechanical principles  $r = ,39$ ;

Machining Workers:

Mechanical principles  $r = ,33$  arithmetic  $r = 32$ ;  
intelligence  $r = ,28$ ;

Mechanical Repairman:

Arithmetic  $r = ,36$ ; mechanical principles  $r = ,35$ ;  
intelligence  $r = ,34$

With regard to training in an industrial set-up the electrical workers' performance could apparently be better predicted than the other two types of workers which is comparable with the work done by Fitters and Turners.

2.2.3 The relationship between aptitude test results and trade test results - Fitters and Turners

Like in the case of Electrician apprentices, the cut-off score for apprentice Fitters and Turners is a stanine 6 on the aptitude tests Mental Alertness, Computation and Mechanical Comprehension. The results obtained are as follows:-

TABLE IV

Cut-off score of 6 on all 3 tests and trade test results

		<u>TRADE TEST RESULTS</u>	
		FAILED	PASSED
Aptitude Test Results	Obtained a stanine 6 on all 3 tests	4 (3%)	29 (24%)
	Did not obtain a stanine 6 on all 3 tests	39 (32,5%)	48 (40)%

The efficiency ratio =  $\frac{29 + 39}{120} \times \frac{100}{1} = 56,6\%$

This efficiency ratio is not very high and as was the case with the Electrician apprentices it was decided to add the stanines obtained by the apprentices together to see whether a better result could be obtained.

TABLE V

Cut-off score of 18 on 3 tests and trade test results

		<u>TRADE TEST RESULTS</u>	
		FAILED	PASSED
Aptitude Test Results	Score of 18 and above	12 (10%)	44 (37%)
	Score of 0 - 17	31 (26%)	33 (28%)

The efficiency ratio was  $\frac{44 + 31}{120} \times \frac{100}{1} = 62,5\%$

This efficiency ratio is an improvement on the efficiency ratio of 56,6% obtained for the cut-off score of a stanine 6 on all 3 tests.

The expectancy chart based on the adding together of the three tests is as follows:-

TABLE VI

Expectancy Chart to predict success in the fitting and turning trade test

Test Scores	Chances in 100 to pass trade test
22 - 27	88%
19 - 21	70%
16 - 18	65%
14 - 15	54%
3 - 13	33%

0 10 20 30 40 50 60 70 80 90 100

A cut-off score of 14 gave the best efficiency ratio, namely 70,8% and is, therefore, the new recommended cut-out score.

The correlations between aptitude test results and trade test results; the intercorrelations between tests, and averages of apprentice Fitters and Turners are as follows:

Number of Cases = 120

## Intercorrelations

Mental Alertness and Computation	= ,59 (,1%)
Mental Alertness and Mech. Comprehension	= ,45 (,1%)
Computation and Mechanical Comprehension	= ,41 ( 1%)

<u>Averages</u>	<u>Stanine</u>		
Mental Alertness	7	(Raw	Score
		17,4)	
Computation	6	(Raw	Score
		14,2)	
Mech. Comprehension	5	(Raw	Score
		15,9)	
Average three tests	17,2		

## Correlations between aptitude test results and trade test results

Mental Alertness and Trade Test Results	= ,2965 (5%)
Computation	= ,3072 (5%)
Mechanical Comprehension	= ,3233 (5%)
Mental Alertness + Computation + Mechanical Comprehension	= ,3967 (5%)

Although the differences between the correlations are small the Mechanical Comprehension Test (,3233) seemed to be the best predictor of trade test results. Prediger (et al. ) found that tests measuring mechanical insight and knowledge correlated ,44 (average of 6 studies) with school courses termed "machining", while the average correlation of arithmetic/computational tests with machining was ,35 and the average correlation with verbal intelligence tests was ,25.

The Computation Test correlated ,3072 with trade test results while Mental Alertness, which can also be classified as a verbal intelligence test, gave the lowest correlation (,29) with regard to the Fitter and Turner trade test.

Of greater interest is, however, the earliest correlations quoted by Ghiselli and Brown (1951) for machining workers. These correlations are given again and the correlations obtained in the present study are given in brackets:

Mechanical principles  $r = ,33$  (Mechanical Comprehension  $r = ,3233$ );

arithmetic  $r = ,32$  (Computation Test  $r = ,3072$ );

intelligence  $r = ,28$  (Mental Alertness  $r = ,2965$ ).

The correlation between the stanines of all three tests added together and trade test results was ,3967 which was higher than the correlation of any individual test with the trade test results.

#### 2.2.4 The relationship between aptitude test results and trade test results - Boilermakers

The cut-off score for apprentice Boilermakers recommended by the Aptitude Test Centre is a stanine 5 on all 3 of the following tests - Mental Alertness, Computation and Mechanical Comprehension. The results obtained when scores are tabulated according to trade test results and these cut-off scores are the following:-

TABLE VII

Cut-off score of 5 on all 3 tests and trade test results

TRADE TEST RESULTS

		FAILED	PASSED
Aptitude Test Results	Stanine 5 on all 3 tests	2 (3%)	8 (12%)
	Did not obtain a stanine 5 on all 3 tests	5 (7%)	53 (78)%

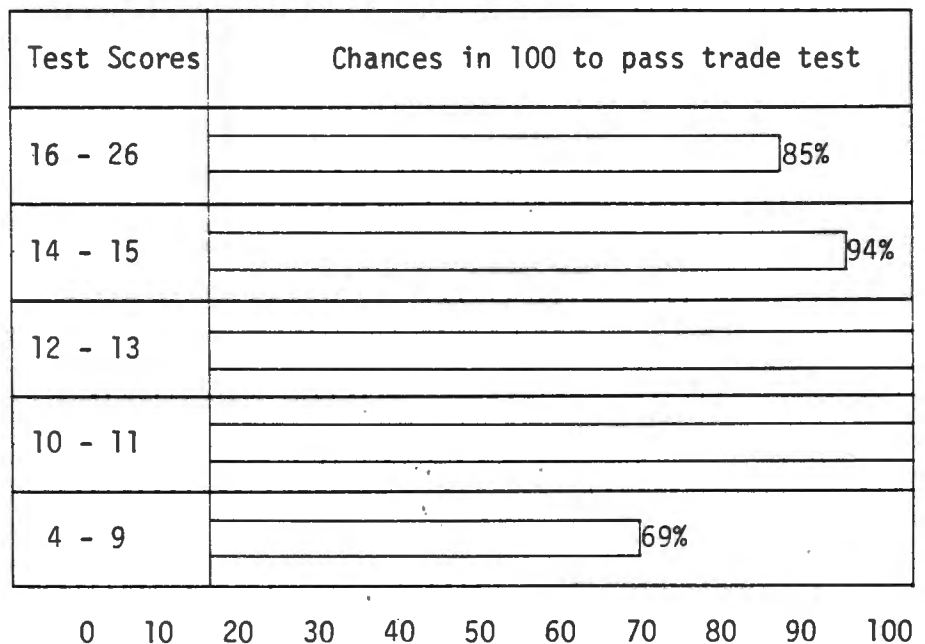
The efficiency ratio for the results is  $\frac{8 + 5}{68} \times \frac{100}{1} = 19\%$

It is obvious that if there is strict adherence to this cut-off score 78% of applicants that passed their trade test the first time would be rejected.

It was, however, decided to develop an expectancy chart, although its practical use in view of the low failure rate would be minimal. The expectancy chart based on the addition of the stanines obtained in the three tests is as follows:-

TABLE VIII

Expectancy Chart to predict success in the boilermaking trade test



As can be seen from the expectancy chart there seems to be little relationship between aptitude test results and trade test results. It must, however, be stressed that a formation of this nature could be expected in view of the small sample (68) and the low number of failures (7). Of interest is, however, the fact that 4 of the 7 failures, or 57% had test scores of 4 to 9. By using 10 as a cut-off score more than half of the failures can therefore be eliminated. The correlations and other statistics follow.

Intercorrelations

Mental Alertness and Computation = ,27 (5%)  
 Mental Alertness and Mech. Comprehension = ,27 (5%)  
 Computation and Mechanical Comprehension = ,19 (no significance)

Averages

Stanine

Mental Alertness	5	(Raw Score 1)
Computation	5	(Raw Score 1)
Mech. Comprehension	4	(Raw Score 1)
Mental Alertness + Computation + Mech. Comprehension	1	

Correlations between aptitude test results and trade test results

Mental Alertness and Trade Test Results = ,2054 (10%)  
 Computation and Trade Test Results = ,07346 (not significant)  
 Mechanical Comprehension and Trade Test Results = ,03177 (not significant)  
 Mental Alertness + Computation + Mechanical Comprehension = ,0943 (not significant)

In view of the relatively small sample and the small number of failures, the abovementioned results should be interpreted with caution. With regard to the correlations between aptitude test results and trade test results only Mental Alertness is significant, but only at the 10% level.

The fact that the correlation for all three tests is on ,043 can be explained by the negative correlation between Computation and trade test results and the near zero correlation between Mechanical Comprehension and trade results.

## 2.2.5

### Conclusions

As can be seen from the results the recommended cut-off scores are considerably lower than the general cut-off score of a 6 on all three tests for Electricians and Fitters and Turners, and a cut-off score of 5 for Boilermakers on all three tests. As were discussed previously, a cut-off score of 14 for Electricians and Fitters and Turners were recommended when adding the stanines obtained in Mental Alertness, Computation and Mechanical Comprehension together. If 14 is divided by 3 (for 3 test results) an average of 4,6 is obtained. For Boilermakers a cut-off score of 10 was recommended which, when divided by 3, gives 3.3.

At this stage it would perhaps be useful to compare the recommended cut-off scores of the Department of Manpower Utilization with the present recommended cut-off scores.

The Department of Manpower Utilisation divides trades into 4 categories.

Category 1 is the highest group of trades (e.g. instrument maker, tool and jigmaking, aircraft mechanic) and a stanine 6 is required for these trades. Electricians and Fitters and Turners fall in the second category and a stanine 5 is required.

Boilermaking falls in the third category and a stanine 4 is required.

Welding is one of the trades falling in the fourth category and a stanine 3 is required.

The Department of Manpower Utilisation also makes use of a system of adding of stanines obtained in different tests. In other words a high score obtained in one test can compensate for a low score in another test.

The question could be asked whether the tests and norms used by the Department of Manpower Utilisation can be compared with those of the Aptitude Test Centre.

The aptitude tests used by the Department of Manpower Utilisation measure with a few exceptions basically the same aptitudes as those used by the Aptitude Test Centre. The question is, however, whether the norms on which these tests are based are the same. The tests used by the Department of Manpower Utilisation are based on a norm grade of people with an educational qualification from standard 6 to 10 that are handled by the Department for employment purposes. The Mental Alertness Test and the Computation Tests are based on a norm group of apprentices with an educational qualification of standard 7 to 9. These norms were developed in 1965. The Mechanical Comprehension Test was standardised in 1971 on a norm group of 130 apprentices with an educational qualification from standard 6 to 10.

(If it can be assumed that there were more standard 10 than standard 6 apprentices in this sample, then this is possibly one of the reasons why the average stanine obtained by Electricians, Fitters and Turners and Boilermakers was consistently lower than the average stanines obtained in the Mental Alertness Test and Computation Test).

The average person in both norm groups of the Department of Manpower Utilisation and the Aptitude Test Centre would therefore, possibly both have an average of a stanine 5. The new recommended score of an average stanine of 4,6

(14 - 3) for Electricians and Fitters and Turners is therefore more or less the same as the cut-off score of a stanine 5 of the Department of Manpower Utilisation.

The recommended cut-off score of 3,3 (10 - 3 test scores for Boilermakers is in actual fact lower than the cut-off score of the Department of Manpower Utilisation. However, this discrepancy can be explained as follows.

As mentioned previously the stanine scale of the Department of Manpower Utilisation is based on a norm group from standard 6 to 10. The stanine scale of the Aptitude Test Centre is based on a norm group from standard 7 to 9 and for the Mechanical Comprehension Test on a group from stanine 6 to 10.

The educational qualification of the Aptitude Test Centre norm groups is therefore narrower and as a result of this it can be expected that the stanine scales would differ, especially at the extremes of the two distributions. As average score of apprentice Boilermakers tended to concentrate towards the lower extreme (the average stanine score of Electricians is 6,2 (18,5 - 3); the average stanine score of Fitters and Turners is 5,73 (17,2 - 3); the average of Boilermakers is 4,23 (12,7 - 3) a cut-off score of 5,7 is not inconsistent with the relatively higher cut-off of a stanine 4 of the Department of Manpower Utilisation.

Another factor which makes a lower cut-off score more feasible is the fact that there has been a considerable improvement in the training of apprentices. The better passrate on trade testing is perhaps one pointer to this.

The implication is of course that people with lower ability can be trained to become a fully fledged artisan. A note of caution should, however, be sounded in view of the fact that apprentices are sent to the Engineering Training Centre for pre-trade test training. Training of this nature does perhaps tend to detract from the value of the trade test as it leaves less to the ability of the apprentice.

Another factor which calls for a cut-off score that is not so stringent as was the case with the cut-off score of a stanine 6 on all three tests for Electricians and Fitters and Turners and a stanine 5 on all three tests for Boilermakers is the fact that very few apprentices failed their trade test more than once. For Electricians only 7 apprentices failed more than once. (Altogether 46 out of 165 failed one or more times). The figure for Fitters and Turners was 10. (Out of 120, 43 failed one or more times). There were no repeated failures in the sample of Boilermakers. (Altogether 7 out of 68 Boilermakers failed once).

(Incidentally 3 out of the 7 Electricians who failed more than once had scores below the new proposed cut-off score of 14 and 5 out of 10 of the Fitters and Turners who failed more than once has a score lower than the proposed cut-off score of 14 for Fitters and Turners.

Perhaps it would be fitting at this stage to give a few quotations on the type of aptitude test considered by the Aptitude Testing Centre to be important for the screening of apprentices at the time.

Patterson has the following to say: "It appears that in the skilled trades, as distinguished from unskilled manipulative work, knowledge and information cannot be separated from mechanical ability, and this capacity to acquire and use information is related to intelligence". (Patterson, 1956 : 359).

One of the earlier psychologists Bingham states that: "A person's competence in a trade resides more in his head than in his hands. Manual dexterity is not the primary requisite" (Bingham, 1937 : 126).

A well known industrial psychologist Tiffin writes that:

"A consideration of the skills demanded of the industrial tradesman or skilled machine operator indicates that this employee usually succeeds or fails in proportion to his training and general mechanical comprehension, not in proportion to his basic dexterity. This fact does not mean that successful tradesmen do not need skilled movements, but it does mean that such muscular co-ordination as may be needed can be developed by the majority of tradesmen in training and that it is lack of mechanical comprehension, rather than inability to develop the muscular aspects of the job, that may prevent them from becoming read proficient in this line of work." (Tiffin, 1952 : 126).

Patterson further states: "... in attempting to predict success in training for, or performance in, a skilled trade's measures of manual ability, or dexterity are not as important as ability to acquire technical knowledge, ability to know when and where to apply it, with appropriate skill and ability to understand and plan a process or job." (Patterson, 1956 : 360).

The type of test that is used by the Aptitude Test Centre thus seems to be the correct type of test with which to select apprentices.

The tentative conclusion could be drawn that if the trade test results are a reliable index of artisan ability, then the present selection and training of apprentices is on a high level. By using the new proposed cut-off scores on aptitude tests and strictly adhering to this, even better results could be obtained.

## 2.3. COMPARISON BETWEEN THE INTERMEDIATE BATTERY AND OTIS TEST BATTERY (Trytsman and Wall)

### 2.3.1 Introduction

The main objective of this study was to compare the current apprentice selection battery (Intermediate Battery) with the OTIS Test Battery. The Intermediate Battery developed by the National Institute for Personnel Research, has been used by Anglo American for the last few years for the selection of apprentices. The OTIS Test Battery on the other hand has been used by Iscor for the selection of apprentices with apparent success.

During the course of 1981, apprentice Electricians, Fitters and Turners and Boilermakers were tested on both Batteries. This testing took place at the Aptitude Test Centre and Engineering Training Centre, Welkom and also at the Engineering Training Centre, Vaal Reefs. The sample of apprentices tested varied between the first and the fourth year of training.

### 2.3.2 Discussion

The Intermediate Battery as used in the selection of apprentices consists of the following tests:-

- (i) Mental Alertness - test of general intelligence
- (ii) Computation - test of computational ability
- (iii) Mechanical Comprehension - test of technical insight

The OTIS Test Battery consists of the OTIS Test which tests general intelligence and the associated battery which consists of the following sub-tests:-

- Number Series Test - measures the ability to determine the relationship between numbers in different series.
- Mechanical Knowledge - measures knowledge of mechanical devices.

- Form Perception - measures a person's aptitude in recognising different figures and designs.
- Space Perception - measures aptitude in space perception.

On the Intermediate Battery a testee's score is given as a point on the stanine scale for each of the sub-tests.

In order to be acceptable an apprentice Electrician and Fitter and Turner needs to have a stanine 6 (six) on all three sub-tests. An apprentices Boilermaker must get a stanine 5 (five) on all three sub-tests. OTIS Test Battery a testee's results are given in terms of a Battery Score. For this purpose a Nomogram is used (see Appendix 1) which classifies an apprentice into the category for which he will be best suited.

The Engineering Training Centre at Welkom and Vaal Reefs were requested to supply us with the performance rating and Technical College results per subject, for those apprentice tested. This specific information was requested to be used as criterion measurement in the comparison of the two batteries.

### 2.3.3 PROBLEMS THAT AROSE WERE THE FOLLOWING:

- (i) Persons not appointed as yet
- (ii) Training at the Engineering Training Centre not started or completed yet, and
- (iii) Did not attend the Technical College as yet.

The method of performance ratings at Welkom and Vaal Reefs differs to such an extent that they could not be combined and used as a single criterion measure.

It was then decided to concentrate on the Welkom sample because the sample size was bigger.

## 2.3.4 COMPARISONS OF THE 1979 AND 1981 RESULTS

### 2.3.4.1 Electricians

#### (a) 1979 Study

The study showed that the cut-off points of stanine 6 on all three tests was unrealistic as it only yielded an efficiency ratio of 49,7%. If the stanines were added together and the cut-off of the total was 18 the efficiency ratio only increased to 66,6%. A cut-off score of 14 yielded an efficiency ratio of 74,5%. The correlation between the Intermediate Battery and Trade Test Results was ,3329 and significant on the 1% level.

#### (b) 1981 Study

If cut-off stanines of 6 are used on the Intermediate Battery, only 17,4% would qualify. If the Iscor cut-off points on the OTIS Battery are used 71,7% of the apprentices would qualify. If the Intermediate cut-off points are lowered to 4, then 78,2% would qualify.

### 2.3.4.2 Fitters and Turners

#### (a) 1979 Study

The following cut-off points on the Intermediate Battery give the following results:-

Minimum stanine 6 on all Tests = efficiency ratio of 56,6%. Cut-off score of 18 on all Tests = efficiency ratio of 62,5%. Cut-off score on all Tests = efficiency ratio of 70,8%

The combined Intermediate Battery score had a correlation of ,3967 (significant at the ,1% level) with Trade Test results.

(b) 1981 Study

The following cut-off points on the Intermediate Battery give the following results:-

Stanine 6 cut-off = 26,2% of candidates acceptable

Stanine 5 cut-off = 40,5% of candidates acceptable

Stanine 4 cut-off = 71,4% of candidates acceptable

If the Iscor cut-off point is used on the OTIS Battery 85,7% of the candidates would have been acceptable.

2.3.4.3 BOILERMAKERS

(a) 1979 Study

The following cut-off points on the Intermediate Battery give the following results:-

Minimum stanine 5 on all Tests = efficiency ratio of 19%

This means that 87% of applicants that passed their Trade Test the first time would have been rejected.

A total score of 10 was recommended as a cut-off.

(b) 1981 Study

The following cut-off points on the Intermediates Battery give the following results:-

Stanine 5 cut-off = 11,5% of candidates acceptable

Stanine 4 cut-off = 46,2% of candidates acceptable

Stanine 3 cut-off = 88,4% of candidates acceptable

If the Iscor cut-off point is used on the OTIS Battery 84,6% of the applicants would have been acceptable.

2.4 Conclusion

2.4.1 1979 Study

The study recommended lower cut-off points than were used up to that point. The study also mentions that if Trade Test results are a reliable index of artisan ability then the present selection and training of apprentices is on a high level.

The one point that is however not mentioned that the previous cut-off scores had not been adhered to because 117 of the 165 Electrician apprentices did not obtain a stanine of 6 on the Intermediate Battery (70,5%).

The study recommended the use of new proposed cut-off scores which would ensure better results. This last recommendation however is purely a request to rectify previously lowered (unofficial) cut-off scores.

1981 Study

The study clearly showed that the current cut-off points are unrealistic and need to be changed, especially as seen in relation to the trade test pass rate of 88%.

A significant (1%) correlation between training results and the OTIS Battery was found. According to current norms and cut-off points 60% more apprentices qualified on the OTIS Battery than the Intermediate Battery. No significant correlation could be obtained between Technical College results and the OTIS or Intermediate Battery. Even when the cut-off points on the Intermediate Battery were lowered to a stanine 5 for Electricians and Fitters and Turners and a 4 for Boilermakers, 43% more apprentices qualified on the OTIS Battery.

It was thus found that the test scores were too high in the Intermediate Test Battery and that the OTIS Test Battery was giving better results. It was thus also found that a high correlation existed between OTIS Battery and training results.

During 1983 another check was done on the OTIS Battery and the new proposed cut-off scores and the test was found to be working well.

All the results so far were conducted on White apprentices only because prior to 1982 there were no Non White apprentices to do the selection on.

2.5 RESULTS SO FAR ON FAIRNESS OF APTITUDE TEST BATTERY SCORES ON NON  
WHITE APPRENTICES ON CHAMBER MINES

2.5.1 The Wiehahn Commission was appointed on 21 June 1977 with Professor N E Wiehahn as chairman and some other members to assist.

The commission was asked to examine twelve sections of labour legislation with the view to:

- Adjusting these laws to "provide more efficiently for the needs of our changing times"
- Adjusting the machinery for the prevention and settlement of disputes where required
- Eliminating bottle-necks
- Creating the foundations for sound labour relations in the future

The report deals with eight areas in six chapters and published its recommendations later on. One important chapter as far as we are concerned for this script is chapter 6.

2.5.2 APPRENTICESHIP

"The Commission recommends a change in Government policy with regard to the indenturing of Black apprentices (5.23) recommending that Blacks should be eligible for apprenticeship outside the homelands. It makes provision for remission from apprenticeship service for apprentices called up for military service 5.35.1-3"

2.5.3 On 19 February 1982 the Chamber of Mines issued a circular 8/82 to its members as follows:

Indenturing of apprenticeship of all races

"At the end of last year representatives of the Gold Producers Committee and representatives of the Collieries Committee reached agreement with the Federation of Mining Unions on the indenturing of apprentices of all races on mines, members of the Chamber". (COM CIR 8/82)

This opened up a new field for Non Whites which was previously not available outside the homelands in mines operated by the Chamber of Mines which operated under the closed shop agreement. The conditions of indenturing was spelled out to be done on the same basis as that for White apprentices.

This automatically posed the question whether our present system of aptitude testing and selection in its present form would have any advantages or disadvantages for the other race groups if applied in its present form.

It was planned to employ the first Non White apprentices at the beginning of 1983. As was expected an overwhelming number of applicants were received of whom a very large percentage were rejected because they did not meet the basic requirements for the job. The following are the statistics of the first attempt:

Applications have been received for apprenticeship from Black and Coloured candidates as from March 1983 to January 1984.

TOTAL APPLICATIONS RECEIVED - 1 580  
AFTER SCREENING TO BE APTITUDE TESTED - 417

BLACK APPRENTICES

Electricians	-	179
Fitters & Turners	-	84
Plating/Boilermakers	-	<u>91</u>
		354



At one of the mines in the group which does not fall under the closed shop agreement and is not a member of the C.O.M., tests have been done on Non Whites during 1981 and the analysis and findings so far follows below:

#### 2.5.4 AN ANALYSIS OF THE OTIS BATTERY SCORES OF 47 APPRENTICES

##### 2.5.4.1 Introduction

During 1981, apprentices were tested on the OTIS Test at Ergo. It was decided to analyse the Battery scores of the apprentices and see for which trades they were possibly acceptable. As the sample contained 41 Black candidates, it was felt to be important to do the analysis seeing that they would also be tested on the same test if considered for apprenticeship.

##### 2.5.4.2 Findings

All but two of the Black candidates were acceptable for one or more of the specific trades. Table 1 shows the number of candidates qualifying for each apprenticeship category. 8 of the Black candidates qualified for Electrician, Fitter and Turner, whilst 24 would have been acceptable for Welders, Boilermakers, or Riggers.

It is therefore clear that the test can be used for Black apprentices and that few changes, if any, need to be made.

Table 1

TRADE	Mixed Group	
	BATTERY SCORE	N
Blacksmith/Bricklayer	9,5 - 10,5	10 - 21,2%
Plumber	10,5 - 12,5	21 - 44,7%
Boilermaker/Rigger/Welder	10,5 - 13	25 - 53,1%
Fitter and Turner	12,5 - 13,5	10 - 21,2%
Electrician	12,5 - 14	11 - 23,4%
Electro Mechanic	14 - 14,5	0
Instrument Technician	14 - 15	0
	15 +	2 - 4,2%
	Below 9,5	2 - 4,2%

Table 2

TRADE	Mixed Group	
	BATTERY SCORE	N
Blacksmith/Bricklayer	9,5 - 10,5	10 - 21,2%
Plumber	10,5 - 12,5	20 - 42,5%
Boilermaker/Rigger/Welder	10,5 - 13	24 - 51,0%
Fitter and Turner	12,5 - 13,5	8 - 17,0%
Electrician	12,5 - 14	7 - 14,8%
Electro Mechanic	14 - 14,5	0
Instrument Technician	14 - 15	0
	15 +	1 - 2,1%
	Below 9,5	2 - 4,2%

Whites = 6 - 12,7%

Blacks = 41 - 87,3%

N = 47

From these limited results obtained so far, it appears that the present tests did work well for the Non Whites and seemed not to discriminate against them. Results from a research in Welkom indicates that the average of the Blacks on the OTIS score is slightly lower but everything else remained constant.

Some interesting results were also reported during interviews and findings with the first Non Whites employed as apprentices at Vaal Reefs.

Some were found not be be able to grasp the three dimension concept even after far more time was spent on them.

Those that made the grades are on a par with the Whites. It was found that they study harder than the Whites in the classes and because of being the minority they try harder.

During the selection and interview stage with the Blacks it was found that most of them applied to become Electricians. A lot of them also applied to become an apprentice as they have heard this is an opportunity to further their education and not so much to become an artisan. When told that he would have to work underground as well, he was amazed saying that he thought he would sit behind a desk and learn. After this a lot of them were not interested. Those that are still left are doing very well.

255 Reference is also to be made on a similar question asked in the U.S.A. of the effect on test Battery results on other race groups. We refer to:

Test Report No. 46

"Fairness of the General Aptitude test Battery  
ability differences and their  
impact on minority hiring rates.

Division of Counselling and Test Development  
Employment and Training Administration  
U.S. Department of Labour  
Washington D.C. 20213  
1983

"Any discussion of the racial or ethnic impact of testing must sharply distinguish between two questions.

- (1) Is the test fair to minority group members.
- (2) Does the use of the test produce a racially ethnically unbalanced work force?"

To say the test is fair is to say that the score on the test is an accurate estimate of the persons ability for all groups. Those who hypothesize that tests are unfair to minorities believe that test scores underestimate the ability of minority members. This is a scientific question which can be answered empirically.

#### 2.5.6 ABSTRACT

This paper reviews the now massive general literature showing that psychological tests are fair to minorities. This literature shows that there is no single group validity, there is no differential validity and tests over predict rather than under predict minority job performance. Further evidence in regard to Blacks is introduced from 51 validation studies done by the U.S. Employment Service. G.A.T.B. norms for Blacks, Indians, Mexicans, Americans, Orientals and the majority (Whites) are compared. Although the majority is higher on cognitive abilities, three out of four minority groups are higher than the psychometer. Thus there is a varied pattern of rank orders among groups across jobs of different complexity. In particular it is shown that for jobs of low complexity the addition of psychometric ability is a predictor and hence economic benefits of the use of tests for selection.

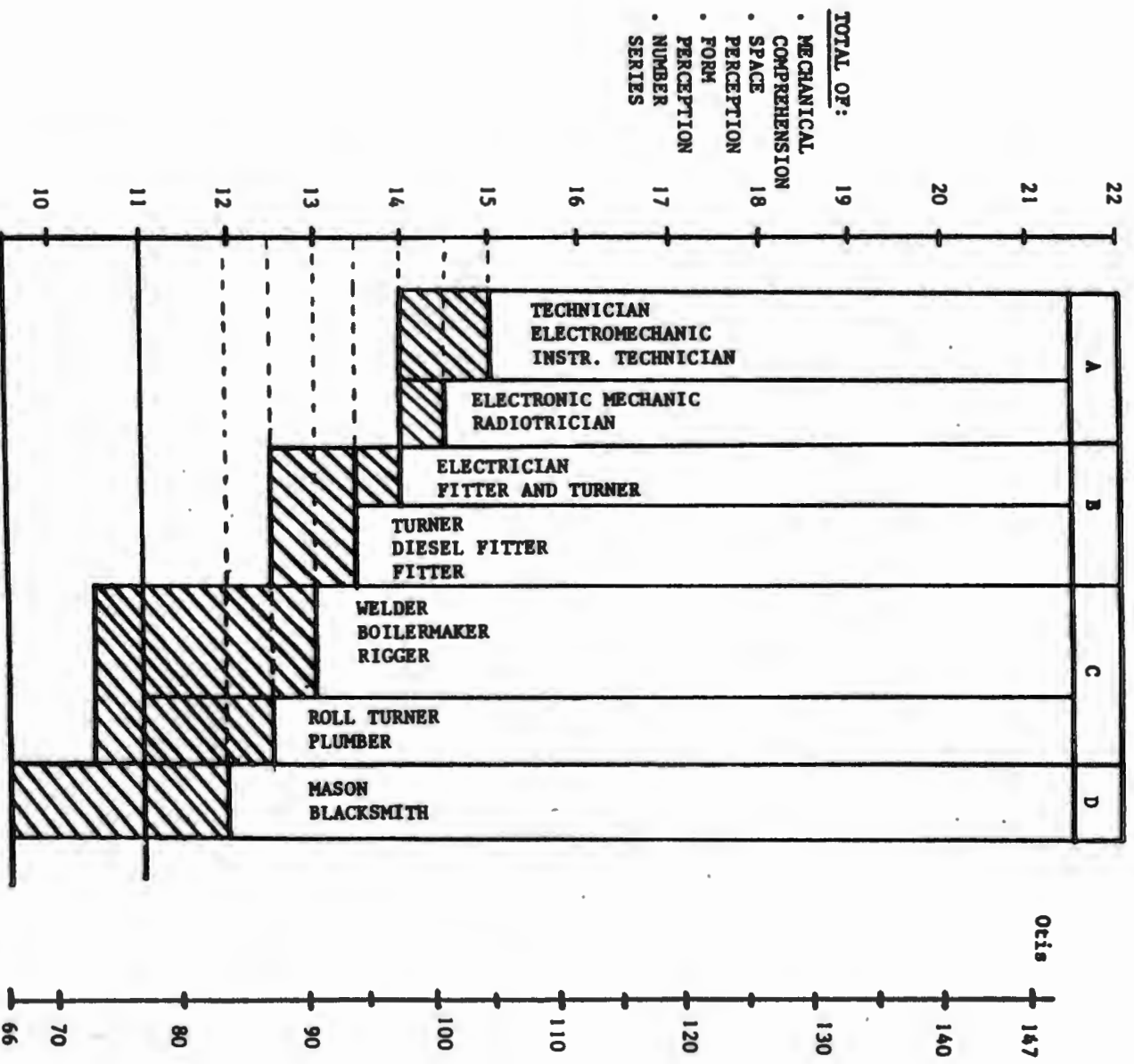
#### 2.5.7 CONCLUSION

The report from the U.S.A. appears to come as good news to us which confirms that the type of psychological and aptitude test used today has a high validity on measuring the basic potential for the skills we need. With our large Non White population which needs training it is also good news to know that we do not need to design special tests to accommodate racial differences.

To conclude this chapter, we may thus say with confidence that our present method of aptitude testing and selection of apprentices is done to the correct standard to ensure that we may make use of all the potential available and if properly trained we may be confident of producing the Competent Artisan which for this exercise is our ultimate objective.

**MONOGRAM - APPRENTICES**

**BATTERY SCORE**



DEFINITELY NOT CONSIDERED

## CHAPTER 3

### DEVELOPMENT OF THE NEW SYSTEM WITHIN STATUTORY REQUIREMENTS

#### 1. DEVELOPMENT OF THE NEW SYSTEM

The reduction of the apprenticeship period from 5 years to 4 years as a phase one, and then as phase two since the two year military training became compulsory to 3 years, created some major problems.

The standard of the trade test was not, and could not be lowered as this would only turn out inferior artisans. The demand on a better trained artisan became more apparent because equipment became more sophisticated and often required a higher skill, both in construction and maintenance than before.

Although there appeared to be a general increase in the number of apprentices that passed their trade tests, this was not a true reflection of the level of improved competency in training but was merely the result of more and more effort being executed in the practising of the trade test pass requirements before the trade test.

Even then, if an apprentice did not pass his trade test, he could still qualify as an artisan by effluxion of time. A lot of criticism came from line as many of these apprentices that were trained lately were found to be very "green" in many ways, although they were often academically highly qualified but had very little practical experience.

During the last decade or two there was also an increase in both the amount and sophistication in much of the equipment due largely to mechanisation programmes on the mines. This only complicated the problem even more.

Except for Apprentice Training Centres which were often centralized in some areas only, most of the mines had individual Technical Training Centres for doing refresher courses as well as specialised training for various trades, post apprenticeship.

A system had been in operation for the last few years to "screen" artisans from outside the mining industry who applied for employment on the mines. The reason for using this system was two-fold:

- Firstly, we sometimes found pretty competently trained artisans from outside industry who were not familiar with our type of equipment and they had to receive some refresher training.
- Secondly, we often found the standard of outside applicants did not meet our requirements. These men would then be rejected or else put onto a retraining programme which sometimes lasted up to between 4 and 6 weeks. Although this was pretty costly to the company, we often did not have much of a choice, especially when there was a shortage of skilled labour.

Due to the many complaints from line that the apprentices completing their indentures on the mine itself did not appear to be up to standard, a ruling was made that all those men also had to be passed out by the Technical Training Centre the same as outsiders coming to the mine for the first time. To our surprise a high failure rate was experienced here as well, which indicated that there was something drastically wrong with our present training system.

This was a cause of serious concern and various methods and means were considered to overcome this problem within the mining companies and among training personnel.

Although considerable changes have been introduced in the methods of training apprentices over the last few decades, these systems were all based on an Instructor Centred Approach and have been biased in their latter stages preparing the apprentices for Trade Tests only.

As was mentioned in Chapter 1, Steyn had identified that the malpractices of the traditional systems were that:

- Its ultimate aim was Grading and not Mastery.
- It did not have specific learning objectives.
- It avoided teaching the Test.
- It was a disguised form of obtaining the Normal Distribution of results.

- It created a condition of "Cumulative Ignorance" and
  - It maintained mediocracy.
- (Steyn, 1976)

The effects of these malpractices were to decrease learning efficiency and effectiveness, decreased motivation of the learners and increased the cost effectiveness of the training.

It is important to note that these malpractices and their adverse effects are applicable to all Chance-Based Systems of training of apprentices only. Furthermore, their negative effects on the countries' efforts to improve the skilled manpower shortage cannot be over-emphasized. When the apprenticeship was still 5 years the apprentice had much more time to do some training and happened to "pick up" a lot more experience as he went along. However, with the new system of reduction and time and more complicated systems and machinery this was not possible any more as he also spent a lot more time at College.

### 3.2 A NEW TRAINING SYSTEM

The Chamber of Mines and the Federation of Mining Unions recognised that any change to the method of training to meet the new demands of training and testing apprentices would best be solved on a joint basis and in 1979 formed a Mining Industry Engineering Trades Training Board (M.I.E.T.T.B.). (We will refer to this as "The Board").

The Board which obtained statutory power in May 1981, consists of 8 members, four from the employers and four from the trade unions. The trade union members are from the:

- South African Electrical Workers Association
- Amalgamated Engineering Unions of South Africa
- The South African Boilermakers Iron and Steel Workers, Shipbuilders and Welders Association and
- The Amalgamated Union of Building Trade Workers of South Africa.

The Board is entitled to establish a fund by levying employers of artisans in the mining industry. The monies raised by this levy are used to further the objects of the Fund which is detailed in the Government Gazette No. 7602 dated May 29 1981.

These objects are many and varied and a few of them are as follows:

- To monitor the selection and promote the engagement of apprentices in the mining industry.
- To investigate, make recommendations on, and if agreed, monitor the introduction of a Competency-based instruction system for the training of apprentices in the mining industry.
- To investigate and monitor the specifications of performance standards in training curriculae.
- To liaise with the Central Organisation for Trade Testing Centre (C.O.T.T.) through the Department of Manpower Utilization and the Department of National Education to ensure that Trade Tests are compatible with the prescribed performance criteria and that the process of trade testing is conducted on an educationally sound basis.
- To introduce, monitor and issue certificates for the recognition of practical training and theoretical courses undertaken by apprentices.

#### Selection of a New and Updated System

After various discussions and looking at different systems especially the work done by Steyn and the obvious advantages and successes of his proposed system of Competency-Based System of Training, the Board committed itself to that system of modular training.

Due to the fact that it was such an important matter, the Board also thought it fit to do additional research at some overseas Training Centres to see how they did similar training with the objective to adopt the best and most suitable system under our present legal situation.

In order to achieve these objectives, representatives of the Board visited training establishments in South Africa and overseas with the objective to see what is going on in other areas as well as other parts of the world. The object was to then gather the best material and methods so as to overcome or improve any deficiencies in our proposed Competency-Based System.

They visited 5 Training Centres in the United Kingdom and 4 in West Germany. This visit included the Engineering Industry Training Board Headquarters in London, the National Coal Board Headquarters, offices and Training Centre in London, Nottingham as well as Headquarters and Training Centres of various German industries eg. Siemens in Munich and Mercedes-Benz in Stuttgart.

### 3.3 OVERALL IMPRESSION AND VALUE OF THESE VISITS

There is a great degree of similarity between the training systems used in the UK and West Germany and there is clearly a positive dedication to the training of apprentices in a systematic and disciplined manner. However, the overall impression was gained that there did not appear to be as many innovations in terms of techniques and aids as was expected, surprisingly more so in West Germany. Nevertheless, the methods used were efficiently implemented and the training was obviously effective.

The general abundance of recruits was considered as possibly the responsibility for the lack of innovative approaches. Sufficient aspects were however considered to compare and evaluate our own systems.

The following interesting points were noted which gave rise to certain recommendations.

#### 3.3.1 Selection of Apprentices

The criteria used to select apprentices by the companies visited appeared to be based primarily on aptitude tests and less on educational qualifications. This is in fact also the case in most of the major mining groups in South Africa.

At present the cut-off requirements for apprentices within our group is a minimum of Std. 8 and 16 years of age, although when a youngster only has a Std. 7, the results of a suitable aptitude test is considered more important for selection for certain trades than the educational qualifications as such.

This method of testing for employment is considered as good enough and it was also recommended by this visiting Committee to recommend this as a standard for the mines belonging to the Chamber over which they had control.

### 3.3.2 Duration of Apprenticeship

This was a very important aspect of checking for the visit. In the countries visited there was a general consistency regarding the duration of apprenticeship. There were minor variations but the duration of an apprenticeship was found to be similar to our local situation.

The Committee thought that our recently introduced system of self-learning and self-pacing modules on the CRI basis may enable some of those apprentices to complete their training in a shorter time than others.

The period of an apprenticeship obviously depends upon selection criteria and training methods. Where we have a shortage of skilled artisans, as at present, and only foresee a greater problem in time to come, the correct selection and training of young men as apprentices is a very important aspect to ensure the necessary standard to be achieved and maintained.

### 3.3.3 Technical College Classes

Both the block release and day per week release system are used overseas.

The method adopted suited the requirements of the parties involved. In our case we have accepted the Block Release System as most suitable and after operating this system for a few years, this appears to be successful and should be kept that way. However, one important point would be that there should be closer liaison between the Technical Colleges, Technicians and Industry to ensure that they meet our requirements and to avoid unnecessary duplication of effort.

#### 3.3.4 On-The-Job Training

Overseas training establishments attached a great importance to the above aspect and it was considered as an essential phase in the training of an apprentice.

The training of an apprentice may be divided into 3 separate phases, namely:

- In a Training Centre
- On-the-Job and
- at a Technical College or Technician.

These training phases must be co-ordinated and controlled and related to each other. Control systems should be built into these programmes and careful and complete records of progress must be maintained.

The amount of time spent in training at a Centre or on the job should depend upon whether the apprentice has learnt the necessary skills and has had an opportunity to practice them and gain expertise in the work situation.

#### 3.3.5 Learning Techniques Found

The Board was surprised that they did not encounter any application of CRI or other similar learner controlled instructional system which was something that had already committed themselves to introduce in South Africa. The circumstances overseas are obviously different from ours and that could be the reason for different systems.

### 3.3.6 Instructor : Qualifications, Role and Ratio

The dedication and enthusiasm of instructors appears to be a universal phenomenon. The value of interested and competent instructors to the mining industry, and indeed to the country, is incalculable. The instructors overseas were also well trained and had to pass special training and courses before they were appointed as instructors.

### 3.3.7 Audio-Visual and Other Aids

Limited use was made of such aids at the institutes visited overseas. This was also a bit surprising as it is a known fact that in the USA and Japan much emphasis is laid on different types of aids to assist in modern and efficient training systems.

### 3.3.8 Conclusion on Visits Overseas and Local

Since their visit overseas, the Board members also visited Training Centres of some of the major mining groups. They were impressed with what they saw and believed these could compare favourably with the establishments they saw in the UK and West Germany. The high rate of applicants for apprenticeship in the mining industry can be considered as a measure of recognition of the high regard in which its apprentice training scheme is held. The visit overseas was also considered to be useful. It enabled these Board members to obtain much information which could be usefully applied to further the objectives of the Board to establish a broader perception of apprentice training in general and to evaluate it more effectively.

## 3.4 PUTTING THINGS TOGETHER

Some 3 500 apprentices are employed by Gold and Coal mines, members of the Chamber of Mines of SA in 14 registered trades. The majority of the apprentices are employed in the 3 major trades, namely, the Fitting, Electrical and Plating (Boilermaking) trades. The distribution is shown in Figure 1.

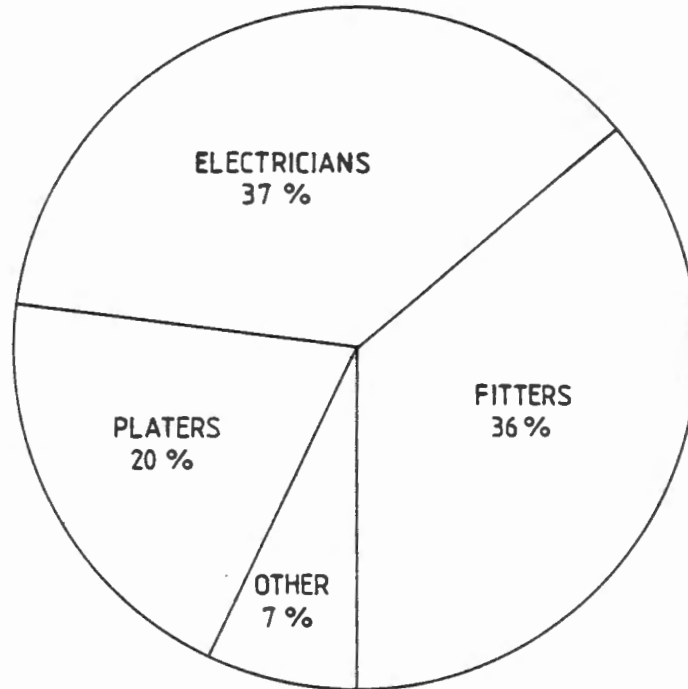


FIGURE 1.

The system which has been finally decided on will however cater for all these, and the only differences will be the legally laid down entry requirements and minimum period of time before the apprentices may enter for their trade tests.

### 3.5 TRAINING PHILOSOPHY

Training can be defined loosely as a process which enables persons to do something which they could not do before they were subjected to that process.

Bebb has given a more concise and very practical definition of the modern concept of training. He defines training as "a method of improving individual performance by the systematic management of the learning of new behaviour to meet the organisation and individual needs".

The modern concept of training is therefore seen to be performance-orientated, based on sound principles of learning and aimed at achieving behavioural change in order to meet clearly defined job needs.

### 3.5.1 Performance orientation

To be effective, training must lead to improved job performance. It is therefore essential when preparing any training programme that the job be examined carefully. This analysis will determine what the learners must actually do and also what they need to know to be able to perform effectively. The modern concept of training stresses that training needs to go beyond an improvement in knowledge. An improvement in work performance is essential.

### 3.5.2 Principles of learning

Educational and industrial psychologists have, as a result of their extensive research work, been able to establish that learning depends mainly upon three factors, namely the learner, the learning material and the learning technique.

### 3.5.3 The Learner

The principles relating to a learner are as follows: Only a learner can learn, he cannot be taught. It is therefore essential to provide a learning situation which motivates the learner. This is best achieved by satisfying the learner's needs for accomplishment, responsibility and recognition during the learning process.

### 3.5.4 The Learning Material

To ensure that learning is effective the learning material must be meaningful, presented in logical sequence and in optimum size steps.

## The Learning Techniques

The following points are important when selecting a learning technique:

- Learning is most effective when it is applied in practice. Passive learning should be avoided and active participation must be encouraged.
- A feedback system should be built into any programme. This feedback must be an ongoing process and should enable the learner to identify and correct his own errors.
- Learning is reinforced by practice and controls should be reduced as performance improves.
- The learner should be encouraged to practice what he has learnt in as many different situations as possible.

## Learning Objectives

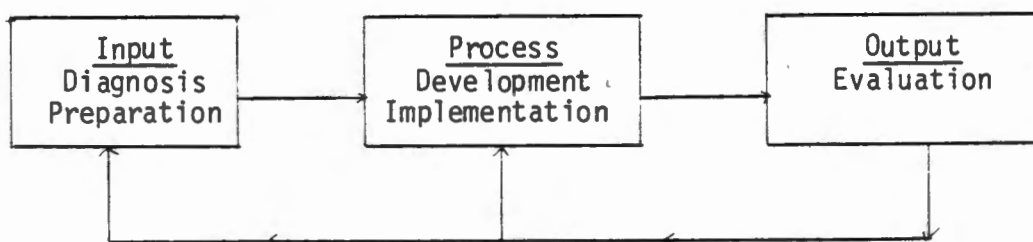
If learning is to be effective it is important that the learner and the trainer should know precisely what is required.

Clearly defined objectives stating the performance required, the conditions pertaining, and the required standards are therefore most essential.

The criteria referenced instruction (CRI) approach developed by Mager & Pipe has been the basis of the process used. Appendix A shows the difference of the conventional systems compared to the competency based system.

## Systematic Approach

Figure 2 : Systems Approach



- 3.5.7.1 Diagnosis is essentially an analysis of the performance problem in order to determine whether training is the most economic and effective method of improving performance.
- 3.5.7.2 Preparation takes place after training has been selected as the best solution. The course developer(s) determines the objectives and performance standards required, measures the skills which are already in existence and selects the method of measuring the degree of improvement.
- 3.5.7.3 Development is concerned with selecting the best learning materials, techniques and strategies. The feedback system is considered during this stage.
- 3.5.7.4 Implementation entails carrying out the training programme.
- 3.5.7.5 Evaluation is the final step and consists of evaluating the training so that the efficiency and effectiveness can be improved further.

The next section explains in more detail how this philosophy was applied in practice.

### 3.6 DEVELOPMENT AND INTRODUCTION OF A COMPETENCE-BASED SYSTEM OF INSTRUCTION

#### 3.6.1 Preparation and development

Preparation of the modules for the electrical trade started in the latter half of 1979 and work commenced on the plating and fitting modules in early 1980.

Course development committees were formed by requesting all the large mining houses, The Colliery Training Colleges and the respective trade unions to nominate members. The individual members' experience covered metalliferous and coal mines and their occupations varied from training managers and instructors to tradesmen engaged on the shop floor or underground. The greater majority of them had no real experience in developing training material, but they were experts in their own trades.

An index of fitting modules showing one example of such a module is given in Appendix B.

### 3.6.2 Implementation

The support of the numerous group training centres in implementing and evaluating the new system cannot be overemphasized. They have played an invaluable role in the development of the system.

Needless to say there have been problems, difficulties and differences but this is to be expected when one considers that the "old" systems have been "efficient" and that each group or training centre has its own priorities and approaches.

The competence-based system is essentially one of self-learning and self-pacing. It requires many aids in the form of "mock-ups", display boards etc., and until these aids are developed fully the system cannot progress as planned. Fortunately, the stage has now been reached where the training centres have nearly all the aids.

The system does not only require material inputs, it also needs instructors who are aware of the benefits which can accrue; are trained in the techniques and perhaps most importantly, are committed to their changing role.

The role of the instructor in the system being introduced differs considerably from that required in the conventional tell, show and do method. The new role is much more demanding and complex and entails more skills than merely those of being the resource. More specifically the instructor becomes a coach, a problem solver, a controller, an examiner, and an administrator. He has to contain his natural desire to "tell it all" and must encourage the learners to solve their own problems.

Whilst there are course maps to guide the learner through the various modules, it is obvious that they are only guides and a flexible approach is necessary. The eventual route is determined by the layout of the workshop; the availability of the necessary equipment, and by the number of apprentices undergoing training.

The ratio of instructor to apprentices varies considerably in the different training centres of the mining industry. Experience to date has shown that the average ratio should be 1:10 in the 3 major trades. However, this ratio can vary according to the job being learnt; in some instances it may be as low as 1 : 2 or as high as 1 : 25. An important point to bear in mind is that every apprentice may be learning a different skill at the same time and thus the demands upon the instructor can vary enormously.

An effective, simple control system is essential. This system should, amongst other things, indicate the progress of each individual, the number of attempts needed to pass each module and the common problem areas. It must also be such that the possibility of cheating the system is reduced to an absolute minimum.

### 3.7 ACHIEVEMENTS AND PROBLEMS

The new competence-based training system for all electrical, fitting and plating apprentices has been introduced in the engineering training centres of the main mining groups, members of the Chamber of Mines, and at the Collieries Training Colleges since January 1982. The modules are also being used by other mining companies and are available to any mine which contributes to the Mining Industry Engineering Trades Development and Training Fund.

It is already apparent that there are many benefits and they will be discussed briefly in this section. There have been various problems associated with the development of the modules and these problems will also be discussed in this section.

#### 3.7.1 Benefits

The main benefits which are becoming evident are:

- the apprentices trained by this system are much better equipped to work in the real job situation. This of course was expected and was a main reason for changing to a competence-based system.

- training time is reduced or, conversely, many more skills are learnt in the same period of time.  
This is a somewhat qualitative assessment at this stage and data is being collected to validate it. A problem is, of course, that the period of apprenticeship cannot be reduced below certain statutory periods. Hence it is obvious that the training time may be utilised more effectively.
- meaningful performance objectives, standards and criterion tests have been accepted on an industry wide basis.  
This has obvious advantages when persons are seeking employment in one group after being trained in another.
- qualified artisans who are lacking certain skills because of the rate of changes in technology can easily be re-trained by the available modules. This is particularly the case in fields such as electronics, pneumatics and hydraulics.
- the apprentices are better motivated by the new approach.  
This is most noticeable and was highlighted by apprentices who were not involved in the earlier trials requesting to join in. It is quite clear that the apprentices react favourable to becoming more concerned with their own progress. However, it should be mentioned that some lads were opposed initially to the self-learning approach. They preferred to be "told it all" - this, of course, is an inherent feature of our schooling system - and a much regrettable one.
- the cost effectiveness of training should be improved.  
Data has yet to be obtained over a long period of time to support this claim. Indeed, it may be difficult to substantiate quantitatively in the future. It is a critical area and efforts will be made to justify the cost effectiveness of the new system.

### 3.7.2 Problems Encountered

An undertaking of this size and nature must be expected to encounter problems and to make mistakes, this indeed was the case. Some of the more serious problems or mistakes met during the development and implementation stages are discussed below. This may be of assistance to others who intend introducing similar programmes.

### 3.7.3 Developments

Some developments were the following:

3.7.3.1 A major problem area was that too much was expected of the members of the course development committees. The majority of them were experts in their trades but had too little experience in developing and, more particularly, in writing training modules.

Despite the fact that they attended courses on methods of developing and writing modules, a large number of them did not attain the necessary skills. This should have been expected and avoided.

The problem was overcome by giving additional training and practice to a selected group of persons. Guided practice was essential and became possible once the numbers involved were reduced to a manageable level.

When training programmes are developed for the other trades, the approach will be to use all the subject matter experts to complete the task analysis and then select and train a few of them to compile the resource material.

3.7.3.2 There was a tendency by the course developers to include far too much material in the resource books. In particular, an excess amount of "unrequired theory" was included.

Even though a considerable amount of editing has taken place there is still some material which should be removed. Peter Pipe emphasized the importance of keeping first drafts of modules as "lean" as possible. His experience has shown that it is much easier, and effective, to add material to, rather than to remove it from, first drafts.

The essential problem here is to avoid having either too much or too little detail. The general tendency is to include too much detail.

- 3.7.3.3 A suggestion has been made that in certain instances the language used in the present modules is far too formal.

The aim should be to write in a style which is easily readable by the apprentice but which does not allow misinterpretation. This is a difficult problem to overcome and requires experienced editors who can edit from the reading level of an apprentice. A technically minded person is not ideal for this work.

- 3.7.3.4 All the modules have been prepared in both official languages. This has added considerably to the work load but is obviously most essential.

It appears as if many of the technical terms in Afrikaans are not used by apprentices - the English term is more common. However, this will be overcome by using the correct terms and, if necessary, issuing a bilingual "Glossary of Terms".

It is important to realise that the modules are not meant to train in fluency in either of the official languages. This is a different training problem and must be approached separately.

- 3.7.3.5 Close and continual contact must be established and maintained with all interested persons during the development stage. This feedback is essential if the modules are to be accepted. However, a situation must not arise where the expertise of the course developers is hampered by the views and opinions of external committees.

It is most important that the technical contents of the modules be approved by the subject experts. The method of presenting this material is the responsibility of the trainer who will obviously be guided by the feedback he gets from the learners and from their instructors.

### 3.7.4 Implementation

- a. Everyone involved with the implementation of a new training programme should be made aware of what is required, why the changes are being made, and how it will affect them. The natural resistance to change and new ideas can only be overcome if interested and involved persons do not feel threatened.

This was particularly the case of the shop-floor instructors. During the implementation of this programme their work role has changed considerably and in some cases they have felt threatened and overworked. An effective introductory course is essential to avoid this.

The course must explain the role of the instructor and must emphasize that he is no longer the main source of information. He must be encouraged to inhibit his natural tendency to instruct. This is not to say that instruction is sometimes not necessary but rather to limit it to the minimum.

- b. A considerable number of mock-ups, display boards and equipment are needed with the new training programmes. Even though this has been costly it is interesting to note that the costs incurred have been accepted as justifiable because of the expected improvements in training.
- c. The first course maps did not allow the apprentices many avenues for progress. This meant that there was considerable congestion and delays. However, this has been overcome and most training centres amend their course maps to suit their circumstances and needs.

### 3.8 FUTURE PLANS

The training programme for the 3 trades mentioned above will now be consolidated. This will entail making the changes discussed in the previous section, backing up the written word with audio-visuals where necessary and ensuring that the on-the-job and "off-the-job" programmes and the technical college classes are related to each other. Work has commenced in developing similar programmes for other trades.

Suitable audio-visuals are not readily available and the Board has agreed to develop its own material, if needed. This is, of course, an expensive media and the benefits must justify the expenditure.

"On-the-job" programmes must be seen as back-ups for practice and skills learnt in the training centres. The Chamber of Mines is investigating this matter and has issued guidelines. Individual mines and groups will be expected to develop and implement their programmes and, hopefully, an industry wide programme will be approved in the future. Effective control systems and records are essential and will be developed.

Close liaison is needed between employers and technical colleges to ensure that the facilities and services offered meet the requirements and avoid unnecessary duplication. The mining industry intends to improve this co-operation in the training of apprentices.

#### APPENDICES

Appendix A - Basic Differences Between Traditional and Competency-Based Instruction.

Appendix B - Fitting Index and Extract from a Fitting Module.

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 BASIC DIFFERENCES BETWEEN TRADITIONAL AND COMPETENCE-BASED INSTRUCTION
 

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 TRADITIONAL INSTRUCTION  
 (Norm-referenced)

 COMPETENCE-BASED INSTRUCTION  
 (Criterion-referenced)
 

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 EXPECTATIONS REGARDING ABILITY AND MOTIVATION
 

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| 1. Not all learners can pass; their results will approximate a normal distribution (spread around the average) because of hereditary and other factors. | 1. All the learners who have been selected for a course can pass; their results will be classified into learning objectives achieved/not achieved. |
| 2. Motivation is a prerequisite for learning success - "You can lead a horse to the water, but ....."   | 2. Learning success is a prerequisite for motivation - "Nothing succeeds like success".  |
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 ULTIMATE AIM OF INSTRUCTION
 

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| 3. The aim is to develop each individual 'to the maximum of his ability' and to grade his relative achievement in relation to the average of his group (ie. in terms of the NORM or relative standard). | 3. The aim is to develop each individual to become competent and measure his absolute ability with reference to achievement of learning objectives (ie. in terms of the CRITERION or absolute standard). |
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 COMMUNICATION OF LEARNING OBJECTIVES
 

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|---|---|
| 4. The idea of 'objectives' is accepted but specific objectives tend to be seen as 'spoon-feeding'. Learners are expected to discover or guess what they are expected to learn. | 4. Objectives define competence; they are clearly communicated to learners in terms of: <ol style="list-style-type: none"> <li>a. WHAT they must be able to DO</li> <li>b. under what CONDITIONS, and</li> <li>c. HOW WELL, ie. the minimum acceptable performance standards (criteria).</li> </ol> |
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 EMPHASIS DURING INSTRUCTION
 

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| 5. Instructor-centred: The instructor must teach correctly according to a syllabus. He decides on the best method of presenting instruction to the group. Emphasis is on <u>teaching</u> , NOT learning. | 5. Learner-centred: Each learner must learn effectively to achieve pre-stated learning objectives. His methods and resources are varied with reference to the objectives. Emphasis is on <u>learning</u> , NOT teaching. |
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 AIM AND BASIS FOR TESTING
 

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| 6. The aim of testing or evaluation is to grade or rank learners for INDIRECT comparison with each other at the end of the course. | 6. The aim of testing is to compare the learner's performance DIRECTLY with the standards required by the objectives during and at the end of the course. |
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APPENDIX A  
(continued)

TRADITIONAL INSTRUCTION (Norm-referenced)	COMPETENCE-BASED INSTRUCTION (Criterion-referenced)
7. The instructor judges which syllabus content to use for testing and manipulates its difficulty level until it gives scores which approximate a normal distribution.	7. The instructor/learner uses the same objectives for learning and testing; the standards have been pre-determined by functional requirements: They are not manipulated but are attainable by all or most of the learners on a 'go not go' basis.
8. No corrective action is taken to ensure mastery for all at the end of the course.	The test results for each objective are used to take corrective action for mastery learning throughout the course.
9. The techniques of catching out, overload and exposure is used in addition to test normalisation for ensuring a chance-distribution of test scores. 'Teaching to the test' is seen as a malpractice'.	The techniques of traditional instruction to ensure a normal distribution of test scores is seen as a malpractice. 'Training to the test' is essential for maturing important performance standards.

SETTING OF PREREQUISITES FOR COURSE AND LEARNING UNITS

10. Learners are allowed to continue with a new course or higher level learning unit without meeting prerequisite standards necessary for mastery.	10. Learners must meet precourse or unit requirements to ensure that they will be able to master a new course or learning unit; 'cumulative ignorance' is avoided.
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LEARNING TIME VERSUS MASTERY

11. Learning time and the number of tests are kept constant, while the results are allowed to vary between extremes.	11. Learning time and tests are varied as required within total course time, while the results are kept constant at mastery level.
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RESULTS

12. The final scores tend to range from 15 to 85%, around an average of approximately 50%.	12. The results are better expressed as 'objectives achieved'; in terms of % they tend to be all passes, approaching 100%.
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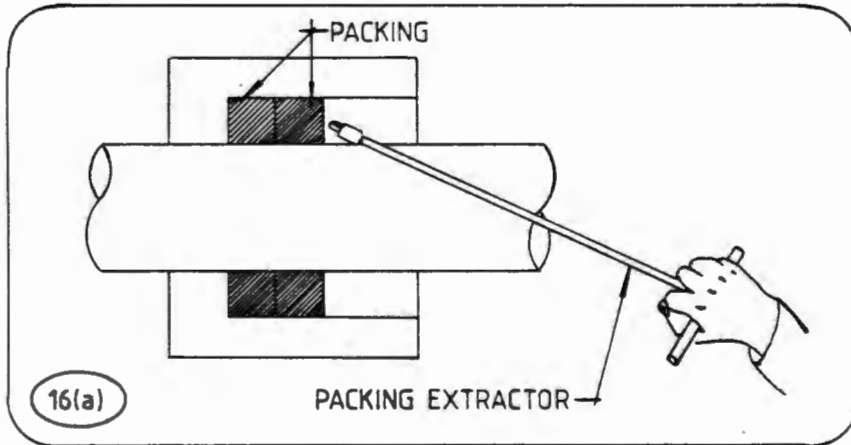
APPENDIX A  
(continued)

TRADITIONAL INSTRUCTION (Norm-referenced)	COMPETENCE-BASED INSTRUCTION (Criterion-referenced)
<u>EVALUATION OF THE INSTRUCTIONAL SYSTEM</u>	
13. Course and test content are evaluated by the judgement of subject experts.	13. Learning objectives are evaluated by direct comparison with job requirements; criterion tests are evaluated by direct comparison with each objective; test performance is directly compared with on-job performance.
14. Instructors are evaluated by whether they have covered the syllabus in the time allowed, and by an acceptable distribution of test scores.	14. Instructors are evaluated by the proportion of learning objective achieved by each learner and by their motivation.
<u>ACCOUNTABILITY</u>	
15. Instructors and management are not held accountable for the achievement of important measureable learning objectives; the objectives have not been specified and the system is not designed for achieving them.	15. Instructors and management can be held accountable for the achievement of important learning objectives; the objectives have been specified and agreed, and the system is designed for achieving all or most of them.

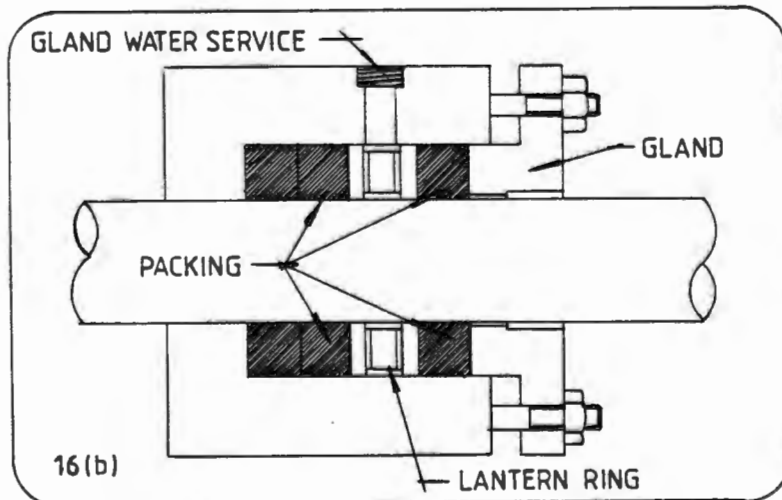
<u>No.</u>		<u>FITTING INDEX</u>
1	DRG	Read engineering drawings
2	MMI	Use measuring instruments
3	HTT	Use a file and a hacksaw
4	KF	Fit a key
5	HTF	Allowances, tolerances and fits
6a	LUB-1	Set a drip-feed lubricator
6b	LUB-2	Pack a plumberblock
7	MMG	Maintain a grinder
8	OA	Use an oxy-acetylene cutting torch
9	OAW	Use welding equipment
10	LM	Lift and move equipment
11	BBS	Temper and grind a chisel
12	TS	Identify threads
13	FT	Fit washers and tighten screws
14	PM	Make up a waterpipe system
15	TC	Cut thread with stocks and dies
16a	SPG-1	Cut and fit gaskets
16b	SPG-2	Fit seals and packings
17	DCC	Align and maintain couplings
18	DBV	Tension and align V-belts
19	CSD	Repair chains and sprockets
20	MDG	Grind a drill bit
21	MDM	Maintain a pedestal drill
22	MPD	Plan a drilling workpiece
23	MDF	Drill a flange
24	FPC	Fit split pins and circlips
25	TRS	Drill and tap holes
26	MTG	Grind toolbits
27	MTM	Maintain a lathe
28	MTP	Plan a turning workpiece
29	MTF	Turn a coupling pin and bush
30	MSM	Maintain a shaper
31	MPS	Plan a shaping workpiece
32	MSF	Shape a stop block
33	MMM	Maintain a milling machine
34	MPM	Plan a milling workpiece
35	MMF	Mill a keyway and hexagon
36	VO	Overhaul valves
37	BIF	Identify and faultfind bearings
38a	BRR-1	Use a punch and dolly one bearing
38b	BRR-2	Heat and fit a bearing
38c	BRR-3	Remove a bearing with an adaptor sleeve
38d	BRR-4	Remove a bearing with a press.

PACKING A GLAND

- \* Remove all the old packing with a flexible corkscrew packing extractor as shown in Figure 16 (a)



- \* Clean the inside of th stuffing box thoroughly.
- \* Examine the shaft or packing sleeve for wear or damage.
- \* Check the shaft for run out with a Dial Test Indicator.
- \* If the shaft runs out more than 0,08 mm, the bearings must be checked or the shaft straightened.
- \* Stagger the joints of the packing rings as follows:
  - a. two rings, joints at  $180^{\circ}$
  - b. three rings, joints at  $120^{\circ}$
  - c. four or more ring joints at  $90^{\circ}$ .
- \* The joint of the first ring must always be at the top.
- \* The packing must be installed in such a way as to position the lantern ring to line up with the gland water service opening. See Figure No. 16 (b)



## CHAPTER 4

### ACCEPTANCE OF THE NEW SYSTEM

#### 4.1 ORIENTATION

As was seen in the previous chapters, this modified or new system was developed out of need that arose mainly because of the reduced time allowed for an apprenticeship as laid down by legislation.

The modified system that the Mining Engineering Trades Training Board (M.I.E.T.T.B.) committed itself to, was not a slow development or evolutionary development of an existing system. The concept adopted was rather revolutionary in that it basically challenged the well-known and generally accepted Traditional Instruction or norm-referenced system by accepting the Competency - Based Instruction or Criterion-Referenced Instruction System as the now system, overnight.

So far we have only described the systems as such but have not spent any time in having a good hard look at the acceptability or actual acceptance of it by the people affected namely:

- (1) The apprentices themselves
- (2) The Instructors
- (3) The End Users of the trained product, that is, Line Personnel.

In this chapter we will discuss the first two items as the third one that is the end user, would be more interested in the results obtained from the skills learned than in the acceptance method of the system and we will discuss that section in the next chapter.

On the other hand we have now reached a stage where we have to subjectively measure the success of a system by going on peoples' opinions or rather our own opinion of what people think and feel. It is not measurable in real terms and like most opinion polls, it may be recorded to indicate what we want to believe it should be.

We have often seen this especially in the political world where opinion counts are taken from the general public and their results then manipulated to suit.

Further on this new system has been in operation for only a relatively short time and if we think back on the Hawthorne experiment we must be careful not to jump to conclusions too soon.

Another problem we must keep in mind is that, because the system has only been in operation for a short period of time, the real success of it should be whether we have met our objective in successful training what we suppose to train, immaterial of whether the method used was liked or disliked by the subjects to be trained. The real success in any training can only be proved in the long run by the results achieved in practice and whatever statements we make, we should clearly spell out the limitations of these under the present circumstances.

We will once again first summarise the "Ideal System" and then measure our existing success rate against this standard.

The main objective of a training system is thus that practically all qualified students (i.e. students selected with the potential) will be able to attain the criterion. Theoretically then all qualified students will be able to attain competence and in our case, it is to reach a level of training where they will pass a final test, i.e. their Trade Test at C.O.T.T. (Central Organisation of Trade Testing at Olifantsfontein).

Basically then, C.R.I. is instruction in which:

- Performance objectives exist for each increment of the course
- All tests are based on these objectives, no more, no less
- A student does not progress to the next increment of instruction until he has exhibited competence at the criterion level
- Objectives are made available to the students in writing at the outset
- Students take criterion tests whenever it is reasonable to think they are ready for them
- Students receive immediate feedback on their test performance
- Rate of progress is determined by the students demonstrated ability. If they can pass a criterion test, they are allowed to go to a next increment of instruction.

These are but a few important prerequisites for a well run and well organised system.

What has been our experience so far?

#### 4.2 STUDENT ACCEPTANCE

When the first electrical modules were issued to the Vaal Reefs apprentice training centre during the latter part of 1979, it was decided to select 6 apprentices to work through these and the remaining apprentices were still trained on the conventional system in the same workshop. Within one week all the apprentices that had been left out of the trials asked to be included as they felt that they were losing out on the learning. This was the first positive indication of the potential new system. Early during 1980, work commenced on the Fitting and Plating modules and as these became available they were also introduced with alarming success.

As was mentioned in the previous chapter, the first complete set of modules have been revised and a complete updated set issued to all the main trades at the beginning of 1984.

The cost of development of the courses was shared by the mining groups and runs into millions of rands.

When a new student enters the Apprentice Training Centre, we can now present him with his full course content and that leaves the student with no doubt as to what he will have to learn and what we expect of him.

The modules have set objectives and it highlights the critical points, contains all required information and instructions and states additional references. In short, it tells the student what he must know, what he is going to do, what equipment or machinery he must use, what is required for him and to what standard it must be done.

There is no guess work in the course or wrong information, it is all positive. The emphasis is on LEARNING, NOT TEACHING and is highly self-motivating.

The first course maximum duration is  $\pm$  12 weeks and all students work at their own pace on the modular system. Although all students start at the same level they are soon spread out at different levels due to learning ability.

The average student completes the course in  $\pm$  8 weeks with an approximate 2% drop out.

A student is immediately tested on completion of a module, given feedback and corrected on any short comings or incorrect procedure.

This form of training has now done away with the conventional training method. In this C.R.I. system the training officer knows what each student is doing at any given time. At a very early stage it indicates which students are not progressing and it makes the student aware of his capabilities.

The set standard in the courses were taken from the C.S.I.R., Bureau of Standards, Manufacturing Standards and Mining Standards. That is the reason why it took quite a long time to develop these modules because great care had to be taken to ensure that it was presented at the correct level in an understandable way.

Student acceptance so far has been overwhelming. We have found quite a great deal of competition taking place among students. As was discussed earlier, it is generally accepted that although competition could be good in cases it could also be degrading in some instances and do more harm than good.

In our case we can only report on the positive aspects as we have witnessed it. In this case students do not compete for the highest marks, because pass mark is 100% anyway.

They tend to compete in progress in the programme that is on completion of the number of modules. Once they have completed one portion they may go onto the next. Once they have completed all the modules in the training centre they are sent out to the different workshops or plants. This seems to be a highly motivating factor.

Some of them even work through their lunch hours and sometimes request to come in earlier. This is a situation that was practically never experienced with the conventional system.

The only acceptable pass mark for the apprentice in a C.R.I. test is 100%. The reason is that once an artisan, he must be able to maintain and install machines and equipment at a set standard which is at a 100% level. If not done so a vehicles' wheel may fall off if all the bolts are not tightened, a motor car engine will not start if the points are not set at the right gap, and an electric unit would not start if not connected up correctly.

The first module in the C.R.I. course is a module on the C.R.I. language and procedure, but it does not take a student long to grasp the new method of learning.

The training officer spends most of his time with the testing of individual students, thereby correcting and giving feedback.

All tests undertaken by the students are measurable and relate directly to the set objective.

The aptitude test is used as the base for apprentice selection. We are therefore pretty confident what a student's technical abilities and potentials are. We have however found that if an apprentice is not performing as he should in one trade it seldom helps to move him to another trade as he tends to perform equally bad for reasons other than ability.

The Gold Division of Anglo American have at present on its books a total of 1180 apprentices split as follows:

Electrical	500	Fitter	419	Boilermaker	207	Rigger	207
Instrument Mechanics	31						

We have an average of 15 to 25 students per training officer.

#### 4.3 ADDITIONAL ADVANTAGE TO STUDENTS

As the C.R.I. course has been implemented by all mining groups belonging to the Chamber as a standard apprentice training system, it is now possible to leave one mine on transfer to join another mine and carry on with his course where he left off. The Chamber of Mines technical training department constantly liaisons with all group mine training centres regarding updating and new additions to module content.

#### 4.4 ACCEPTANCE BY INSTRUCTORS

The role of the instructor is very different under the modular system than the conventional "show, tell and correct" method. The "new" method is more complex and requires many more "skills". It is thus essential that the instructor be qualified and competent in his job as he now has an even more important role to play.

Before the new system was introduced all the instructors were sent on the C.R.I. course to familiarise them with the new concepts and systems. Some of them also assisted in designing and drawing up the new modules.

Discussions were held with different instructors in different training centres and different trades. All of them supported the new system and although they admit it is more hard work they all agreed that they obtain much more job satisfaction.

The general opinion is that the new system is much more self motivating. They find that the young men tend to be more keen to work. They have much less problems with discipline and sometimes their biggest problems are to get the youngsters to stop during their lunch times and tea brakes which are statutory requirements and part of the discipline they have to enforce now.

None of them would ever be wanting to go back to the old system again. It took them some time to reorganise their workshops to cater for the new system. The lecture rooms are now very seldom used for lectures but video equipment and other aids are placed there where the apprentices do their own additional self study. All the instructors emphasised the importance to reorganise and restructure portions of the workshop as well as the importance of training methods, e.g. audio-visual aids as an essential and complementary resource to the modules.

In discussion held with managers of training centres, it was generally felt and agreed that with this new system, the status and level of the instructor must be uplifted. For that reason the (M.I.E.T.T.B.) Mining Industry Trades Training Board is busy drawing up the curriculum for an industry certificate for all instructors engaged in Apprentice Training. The objective is that it must be of a high standard and persons who obtain this must receive an equitable form of recognition.

It is also recommended that the average ratio of instructors to apprentices be about 1:10 for all the major trades. With our present shortage of skilled artisans this new system could assist in training at an increased rate of men in a shorter time with better qualified instructors, thus obtaining a higher pass rate in their trade tests.

#### 4.5 SUMMARY

Although the new system has been in operation for a relatively short period of time and because this was a new system to all concerned the first indications are that it is generally very well accepted by both Students and Instructors. No scientific method of formal opinion or acceptance measurement was used because of the short period of time in operation, but this will be closely monitored to find out by proper feedback methods what else could be done to ensure longer term acceptance and success.

## CHAPTER 5

### THE END PRODUCT

#### DOES HE MEET INDUSTRY REQUIREMENTS?

Training is a method of improving individual performance by the systematic management of the learning of new behaviour to meet the organisation and individual needs. The modern concept of training is therefore seen to be performance - orientated based on sound principles of learning and aimed at achieving behavioural change in order to meet clearly defined job needs.

Therefore to be effective, training must lead to improving job performance. Does this in fact still happen today? What if anything has changed and is so, what did this change bring about? Do we still receive competently trained men who can do the work they have been trained to do effectively?

#### 5.1 HISTORIC DEVELOPMENT

The apprenticeship system has come a long way. Less than half a century ago young men still had to pay to learn a trade. The system then was that a young man who wanted to learn a trade was assigned to a master or craftsman from whom he had to learn his trade. There was no definite time period attached and he was only considered as a competently trained man if so decided by his tutor. In this way some never got their "papers" as qualified artisans but was used as cheap labour for long periods of time.

It was only as recently as 1944 when the Apprenticeship Act was promulgated which spelt out in detail the terms and conditions under which apprenticeship contracts were entered into and the terms and conditions under which apprentices would then qualify as artisans. (Act No. 37 of 1944 as amended).

Although a similar method of training was then still followed, i.e. a young man working with an artisan as his trainer, things were a bit more organised since the new act. There was at least a definite time period specified in this case, 5 years after which this young man was then deemed as having had sufficient training and experience to become an artisan. Later on, certain minimum compulsory theoretical qualifications had to be met at employment, otherwise the apprentice had to go to "night classes" and later on even one day during the week.

The result of this type of training was that the apprentice learned by means of a slow learning process and at the rate his artisan wanted him to learn. The advantage was however that his artisan taught him the things he wanted him to know and considered as important and he had quite a long time to do just that. This apprentice was then often pretty well locked into the system where he obtained his training because often it was only directed to that specific environment and rather specialised.

As companies grew bigger and due to a shortage of skilled labour, management often signed on more apprentices than artisans and also started training centres where the apprentices were taught certain basics which the artisans did not always train him at. For certain practical experience they still worked with the artisans. However, due to the effluxion of time which was 5 years, the apprentice still automatically became an artisan after that time period.

It was only in the late sixties that the trade tests were introduced which enabled an apprentice to reduce his apprenticeship by passing a recognised trade test controlled by the government in the trade test centre at Olifantsfontein. In the initial stages there was a very large failing rate which indicated one of two things.

- (1) Training of apprentices was substandard
- (2) The trade tests were unrealistic

Some companies then started to concentrate their training with the objective to let the apprentices pass the set trade test. Because of various reasons like army commitments the original apprenticeship period of 5 years has today been reduced by law to 3 years allowing an apprentice to write for his trade test after a period of 2 1/2 years, provided he has obtained certain minimum practical experience and theoretical qualifications. If the apprentice does not pass such set trade test he still becomes an artisan due to effluxion of time after 3 years.

## 5.2 The closed shop agreement

Mining companies belonging to the Chamber of Mines are all bound to a closed shop agreement with certain unions. In terms of a provision in page 9 of chapter ix of the publication "Union Men": Notes and Agreements", between the Chamber and the Unions it provides that managements of mines, before engaging artisans should obtain and examine the credentials of the applicants to ensure that the applicant can prove his artisan status.

In terms of the agreement artisan status can only be obtained in one of the following ways:

- (1) The passing of a recognised trade test
- (2) By effluxion of time and
- (3) Artisan status can be conferred upon an individual by a union.

In case of (1) and (2) documentary proof of artisan status is issued by the authorities. In the case of (3) the union issues the artisan with a membership card which clearly indicates that the member is an artisan.

In terms of the union agreement which has been met, such a man may then be employed to undertake any task which in terms of The Mines and Works Act and Regulation may be done by a qualified artisan only, provided he is deemed competent. Such a person may be allowed to undertake certain work for which he is legally appointed and requires him to sign log books, and perform certain work which he may do due to his status as a qualified artisan. The onus is however still on the man who appointed him and who deemed him "competent" to undertake such work.

The million dollar question is now this:

How do we measure his competency or when do we deem a qualified man as a competent man?

When a person who served a recognised apprenticeship either passes a recognised trade test or completes his contract by effluxion of time, he is termed a qualified artisan.

The unions under a closed shop agreement may also under certain circumstances and reasons of their own recognise a man as having "artisan status" and grant him union membership.

Where do we now stand under these conditions regards the "competent artisan: which is the requirement line personnel need for certain classes of work to be done. Unfortunately the onus is on the supervisor or senior who permits, allows or instructs the man to do certain work to ensure himself that the man is completely trained.

In cases where a wrong act performed by this man causes loss in production or damage to equipment it is bad enough but in cases where a wrong act can either cause an accident to the man himself or to other persons using the equipment this may have serious repercussions.

As an example we may quote an Electrician who could kill himself in unsafe acts or a mechanical man causing major equipment, e.g. winders to operate unsafe due to break failure thus injuring or killing other people.

Proof of having artisan status in cases like the above would be of very little assistance to the superior to prove the artisans' competence. In case of an accident caused by the wrong act of such an artisan the inspectorate would ask, "What have you done to ensure yourself that the man was competently trained to do that work?" At one stage the mine thought that the apprentices trained on our own apprentice training centre and who passed their trade tests were competently trained for employment as artisans on the mine.

To double check on the ability of artisans employed from outside the mining industry a system was introduced where all these men were first screened at our Technical Training Centre. They were introduced to our safety procedures and Fanakalo and also checked and interviewed for technical competency. This often resulted in the better ones to be "refresher trained" in this training centre and the obvious badly trained ones to be rejected or retrained for a long period of time.

However, shortly after the introduction of the 3 years apprenticeship period, complaints were being received from line management about the obvious lack of training of our own apprentices who have served only the 3 years by effluxion of time, but worse even, about those that passed their trade tests, in cases with very good results.

We also had the unfortunate experience where a young electrician was badly injured in an electrical accident involving High Tension equipment.

In investigating the accident in detail it became obvious that there was a certain deficiency in our current apprentice training system. We then extended the system of testing "outsiders" in our Technical Training Centre to those apprentices that were trained within our own organisation before we formally employed and placed them.

To our surprise and disgust we found that many of them did not make the grade although they had their papers as qualified artisans.

We then went back to the "drawing board" and had a very critical look at our current apprentice training system.

Following are copies of the total training programme based on the current 3 years for Electricians and Fitters. The Boilermaker one is similar.

Critically analysed we see the following summary of theory, technical and military training.

(1)	Apprentice Training Centre	32 weeks
(2)	Technical College	36 weeks
(3)	Military Training	8 weeks
(4)	Leave	6 weeks
	TOTAL	82 weeks

Total apprenticeship time	156 weeks
- Theoretical training etc	82 weeks
 Total time for Practical Training	 64 weeks

If he passed his trade test after 2 1/2 years, it could mean that the apprentice could spend less than 1 year doing practical training out of the training centre.

In the training centre he worked under virtually ideal conditions with no dirt or dust or other practical environmental conditions.

In investigating what he did in the different practical work conditions outside the training centre, we also found that very often these apprentices were either left on their own or used to do some menial work which contributed very little to their real training needs.

It was also being established that because of the high standard of Basic Training done in the training centre as well as the high level of Technical Training received at College or the Technikon, the apprentices either felt themselves a bit superior towards the lesser "educated" older artisans or found the dirt and dust of the practical work situation not at all that pleasant and tended to "scheme" themselves into easier tasks at the detriment of their own training.

In some cases the artisans also used the apprentices for making tea.

In the "good old days" this could still be tolerated especially in the beginning without much detriment to the youngsters practical training programme because he still had a bit of time in hand. With the current limited amount of time available for practical training this could not be tolerated.

We ended up with Qualified but not Competently trained young men. What could be done? First of all we had to ensure that before we signed a man on, whether from outside or trained inside, he had to be screened and even given additional training if found to be necessary.

Attached is a copy of a very important document which was put forward to our consulting Engineer by the apprentice supervisor and accepted. Appendix 3. We were now forced to retain some of our own apprentices at an artisan rate of pay to ensure competence for his appointment. This was never meant to be the case in an apprenticeship system and also very costly. We had no other choice both from a shortage of artisan and safety point of view.

Although there has been a lot of criticism about the validity of the trade tests, a problem which Steyn had already highlighted in 1976 (Steyn, 1976) this was a Government approved and controlled situation, which not much could be done about. The 3 year period of apprenticeship was laid down by the Act as well, so not much would be done about lengthening or extending the period to have more time for additional training. The only solution was to modify or replan our system to such a way as to produce an end product which could be used for the purpose it was intended to. What additional training could we offer these young men to ensure they would meet the required level of competency or what could we do to bring them up to our requirements if not during their apprenticeship then after the completion of their apprenticeship. We also determine that often the youngly qualified artisan had quite a bit of technical knowhow about the job but lacked self confidence due to not having had enough exposure to the practical side of things. Because of the quick development of technology the last couple of years and because of the nature of the work of the maintenance artisan which constitutes + 80% of all the artisans on the mines, not only a dept of knowledge but also a wide span of different equipment has to be looked after.

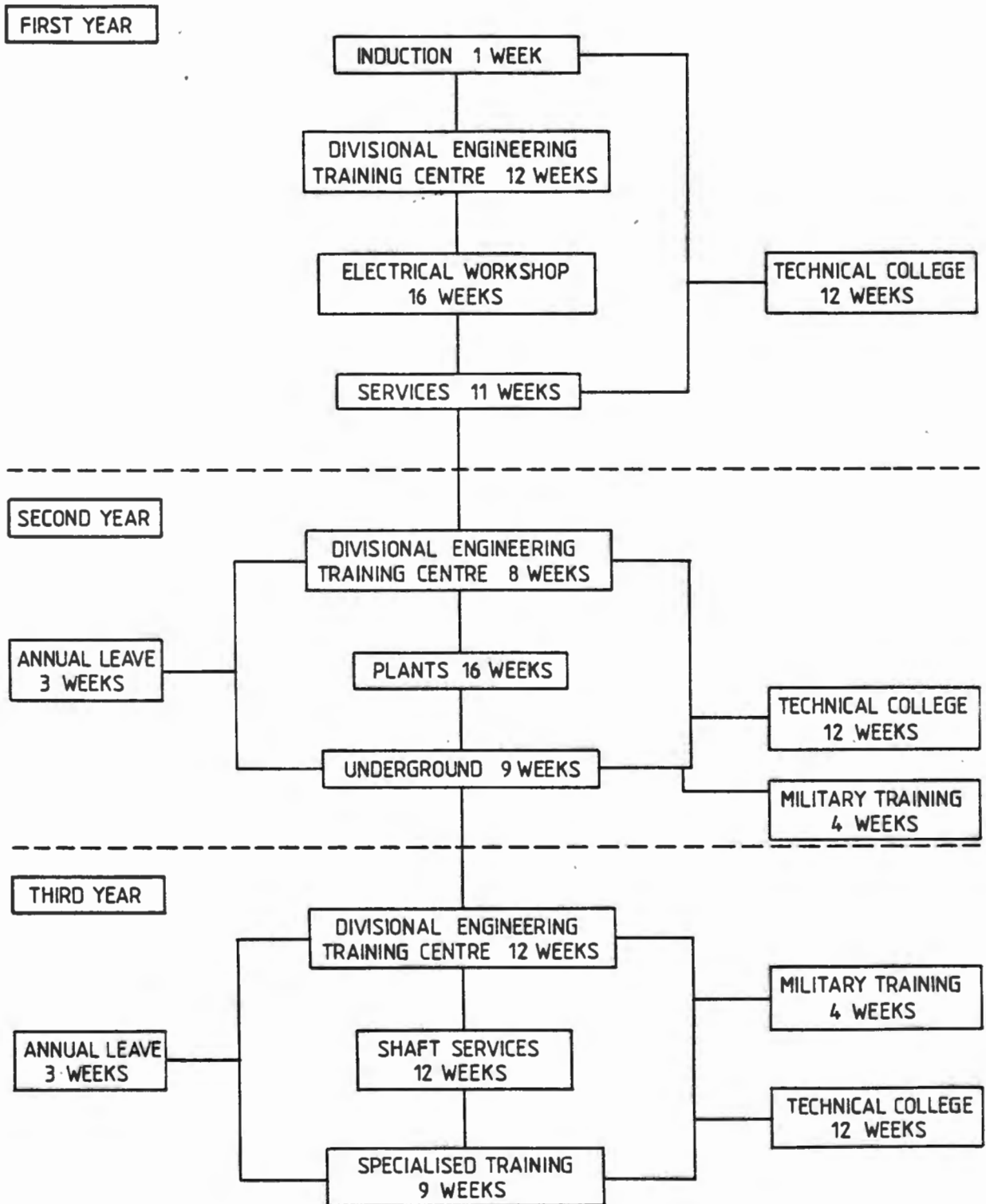
Similar to other industries we also experience a general shortage of skilled artisans from time to time so we were often forced to put a youngly qualified artisan in a large section, sometimes really expecting the impossible under his circumstances. We thought we had the answer with the large success rate of self development with the C.R.I. system. When we struck this problem described, we reassessed our basic training method in the Apprentice Training Centre. It was confirmed that this method was not to be faulted. We had to go and look a bit further.

How could we assist the apprentice in the real work situation to supply him with the knowledge he requires to do his job?

We decided to make use of a newly developed system called "The Employee Development Programme" (EDP). Although this system was not developed for apprentice training purposes, this appears to be a solution to a major problem as will be seen in the next chapter.

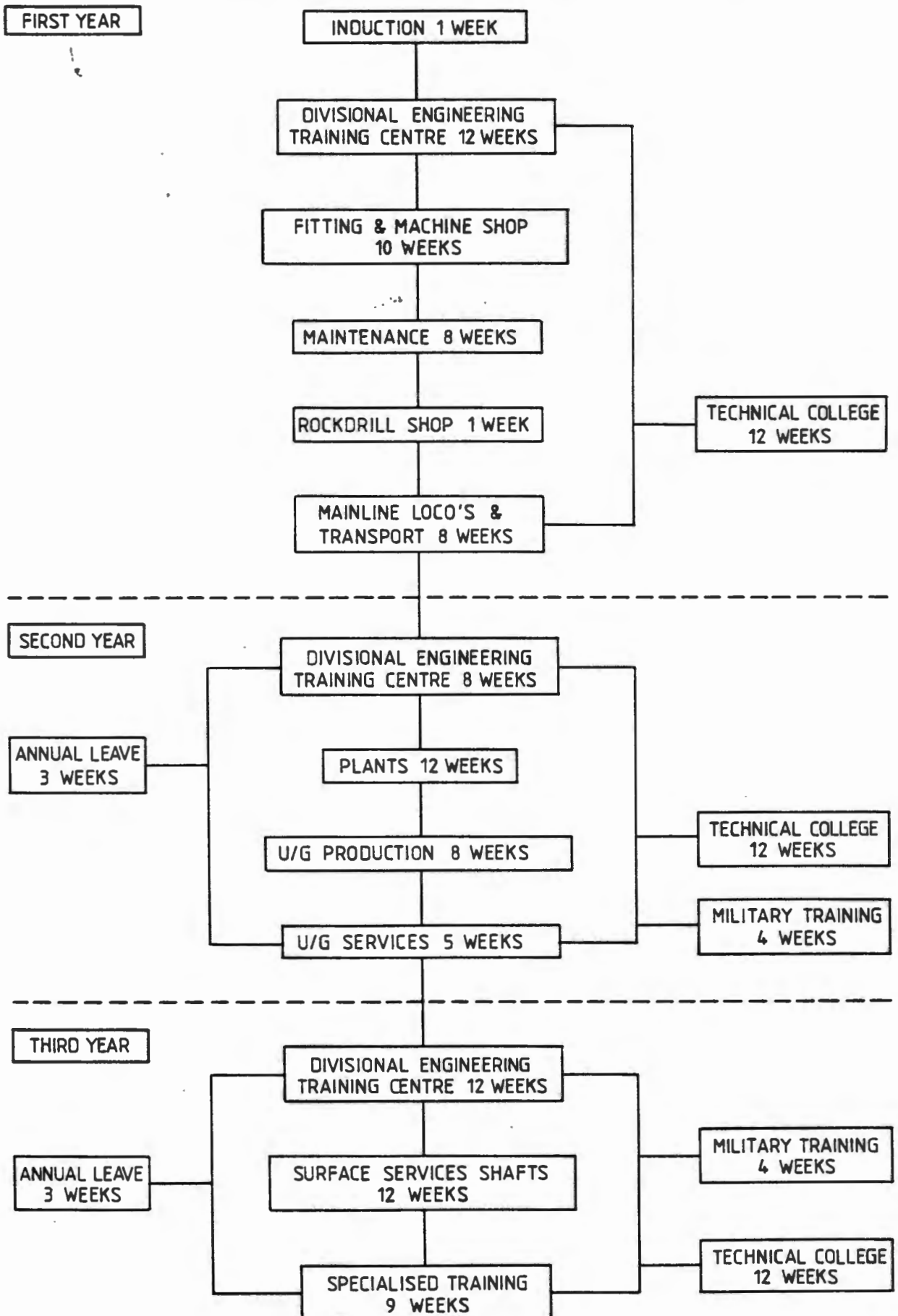
APPENDIX 1.

TRAINING PROGRAMME FOR APPRENTICE ELECTRICIANS  
BASED ON A 3 YEAR APPRENTICESHIP.



APPENDIX 2

TRAINING PROGRAMME FOR APPRENTICE FITTER & TURNERS  
BASED ON A 3 YEAR APPRENTICESHIP.



APPENDIX 3

Mr X  
VAAL REEF

Technical Training Centre  
14th February, 1980

PROPOSED TESTING PROGRAMME FOR APPRENTICES ON PASSING TRADE TEST OR  
COMPLETING INDENTURES :

The new policy states that all artisans must be tested before joining the company, this also effects apprentices, completing their indentures.

Tests will be carried out at the South Training Centre by Mr Y.

If however, it is found that apprentices need more training in certain areas of their respective trades, they will have to spend periods in i.e. workshops or plants or surface (shafts) wherever applicable to gain more experience.

The tests will consist of a questionnaire and practical tests.

Furthermore, it will be of great value if tests could be carried out after an apprentice completes his training in the sections as laid down in the training manual. This will certainly show if training, as prescribed in the manual has actually been done by the apprentice, and if, the apprentices progress was of such standard that he can proceed to the next section.

Due to the short time available for training apprentices, it is of vital importance that all concerned with the training of apprentices do their utmost to ensure that the training should be of the highest standard possible.

Mr Z  
APPRENTICE SUPERVISOR

## CHAPTER 6

### BEGINNING OF A NEW ERA

#### THE IDENTIFICATION OF COMPETENT ARTISANS UNDER THE PRESENT STATUTORY SYSTEM BY MEANS OF THE EMPLOYEE DEVELOPMENT PROGRAMME

##### 6.1 INTRODUCTION

In the previous chapters it was indicated how a series of incidences which changed the training period of apprentices from a 5 year to a mere 2 <sup>1</sup>/<sub>2</sub> year period forced management into the investigation and ultimate redesign of conventionally accepted systems.

Although this change in time period was originally looked upon as a near disaster from a training point of view because it was a statutory change in time, the development of the CRI system by the Chamber of Mines into the newly accepted system to meet this challenge was ultimately considered a blessing in disguise.

Although this newly developed training system was a vehicle to meet the objectives of the apprentice training system, that is to pass the prescribed trade test in the laid down time, it posed a new problem to industry in that the artisan thus produced was qualified in terms of the law, but was found not to be competently trained in terms of production requirements. In other words, it was discovered by the line people that there was a deficiency or "gap" in the newly developed apprentice training system.

##### 6.2 THE EMPLOYEE DEVELOPMENT SYSTEM

In its broadest concept, this programme developed as a strategy to meet the long term Industrial Relations objectives of the Gold and Uranium Division of the Anglo American Corporation as formulated by the divisional project team appointed for that purpose during 1975.

The key objective was to create an environment within which management could make the most productive use of their total human resources with the following specific needs:

- To meet the increasing skill shortage and improve productivity.
- To provide avenues of advancement which could accommodate the aspirations of its employees.
- To alleviate the growing feeling of insecurity held by the White employees.

The EDP was conceived as the vehicle for working towards these objectives since it could be pursued within the statutory, political, economic, sociological and traditional constraints governing the Industrial Relations climate at the time and changes in these areas that could occur in the future.

Labour costs, particularly in respect of Blacks, were becoming an increasingly large component of working costs while Black labour productivity had only marginally improved over the last few years.

The aspirations of Blacks hitherto passive was being expressed more vocally as the Black Unions were starting to emerge.

The insecurity of the Whites at the interface was becoming acute as the Black Unions gained concession in their fight against discrimination and was creating more and more emotional reaction of the Whites, especially to members of the White Mine Workers Union.

For White employees, particularly those at the interface, personal job competence was the best guarantee of security in a competitive environment.

Within this context, the aim was then to supply a modular scheme of training whereby each employee would have the opportunity to upgrade his personal skills to whatever level he wished to and was capable of achieving.

The problem, however, was that as far as the engineering artisans were concerned THERE WAS NOTHING FORMAL by which men could improve their own competence in a formal way except by proven competence in what they were doing.

C. REPORTS

1. AAC Group Training Report, 1977
2. Association of Mine Managers Training Symposium, 1979.
3. Chamber of Mines of South Africa  
Human Resources Monitoring Report, July 1978
4. ROBERTS J.J.  
Developing Effective Managers  
IPM Publication, 1977
5. SINGER E.J. and McDONALD I.D.  
Apprenticeship Outdated  
IPM Publication, 1970
6. THERON H.S. and BARLOW-JONES L.  
The Relationship Between Aptitude Test Results and Trade Test  
Results of Apprentices  
AAC Aptitude Test Centre Welkom, 1979
7. TRYTSMAN H.J. and WALL S.A.  
A Comparison Between the Intermediate and OTIS Battery in  
Selection of Apprentices  
AAC Aptitude Test Centre, Welkom, February 1982
8. U.S. Department of Labour  
Fairness of the General Test Battery Ability Differences and  
Their Impact on Minority Hiring Rates  
Test Report No. 46  
Washington DC, 1983
9. VAN ZYL A.J. (Dr.)  
Prinsipaal, Pretoria Tegriese Kollege  
Meer Tegriese Onderwys, 1965

D. THESES

1. GOUWS P.A.  
Arbeidsomset by Werkers met Bogemiddelde Prestasie in 'n  
Vervaardigings Onderneming  
M.A. Skripsie, P.U. vir C.H.O., 1980
2. LABUSCHAGNE C.E.G.  
Persoonlikheids en Motiveringsverskille Tussen Goeie en Swak  
Ambagslui  
M.A. Skripsie, P.U. vir C.H.O., 1980
3. STEYN G.  
Evaluasie van Praktiese Opleiding van Vakleerlinge in Suid  
Afrika met Besondere Verwysing van Passers in die  
Goudnywerheid  
M.A. Skripsie, R.A.U., 1976

E. GOVERNMENT PUBLICATIONS

The Apprenticeship Act  
Act No. 37 of 1944 As Amended, together with Regulations of The  
Republic of South Africa  
Keartlands' Law Publishing Company (Pty) Limited

However, the mere improvement of job performance could not provide the degree of security which could accommodate the development of a competitive Black/White interface Job Knowledge and skill alone would not be enough.

They must be complemented by a Competency-based hierarchy of jobs in which the individual employee could UPGRADE himself so that his status would reflect his skill differentials and in which his new skills could be used to the advantage of the organisation.

In practice therefore not every artisan could become a foreman, but we had to devise a system which recognized that all workmen within a specific job category are not equal ie. that there are differences in the levels of Performance or Competency. Such a system could identify these differences and reward employees accordingly.

While the EDP had been assembled with the purpose of creating a method of structure to control the development of all employees up to mid-management level, in the short term it had been focused on White employees at the Black/White interface level in the different disciplines, that is, Mining, Engineering and Metallurgy. We will however only concentrate on the engineering discipline, that is, the artisan problem.

### 6.3 THE REAL PROBLEM

In the engineering training system we have formal training systems for apprentices only. Once an apprentice reaches the stage as a qualified artisan, either by passing a trade test or effluxion of time, there is but no formal training system for further advancement. A newly qualified artisan can only improve his level of competency by enlarging his job knowledge and skill by obtaining wider experience.

There is another anomaly in the system which is worth mentioning. Whilst being an apprentice, and as recognition of higher technical qualifications obtained, a senior apprentice may earn as much as R80,00 per month extra.

The moment he qualifies as an artisan, and because of our current union and closed-shop agreement, he starts on the same basic wage as his colleague who has not obtained any additional technical qualifications during his apprenticeship.

So under the current system there is but no way where a newly qualified artisan can do or study anything to improve his position financially or otherwise.

The only way management could thus approach this problem was to design a new system which would be widely enough recognized and which would enable an artisan to improve himself in a recognized and tangible way.

A Module Training System was adopted to eliminate the logistics problem of holding formal courses and provide valuable flexibility in application.

Although the principle of these training modules were discussed and accepted as far back as 1975, it was only about 5 years late, that is during the early 1980's, that the programme really came off the ground.

From a purely training aspect it must certainly be the largest development of this type in the country. Due to its uniqueness, there has never been a clear pattern to follow, so there was no way that a plan, comprising programme schedule and budget could be set out.

#### 6.4 MODULE DEVELOPMENT

A User Committee of each of the mentioned disciplines was formed at a very senior level to guide and develop the system envisaged.

Many problems were experienced in the beginning. One of the most difficult problems was to strike the right balance between the volume of data and the exact logic of doing a task. Communication had to be concise, logical and clear without "padding".

Very early on there was a distinct tendency to overdo task description. The temptation was to retrain the artisan with skills he already had. However, once the concept of the correct starting base was understood and accepted, this problem disappeared.

A major change in concept evolved in the development of the modules as we moved up the learning curve. Instead of one person writing a module, a team of experts from the different mines held a "Workshop" where all the necessary task listings were developed and broken down into details elements of knowledge and skills. These were then further developed into a complete document for each task.

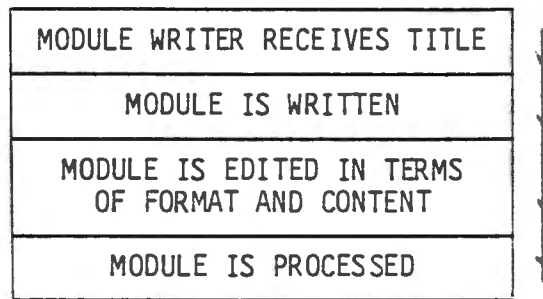
The different mines in the group came together and drew up lists of all equipment that was used as a standard or common equipment. To obtain the biggest benefit and quickest results it was decided to call the common equipment modules Part I.

All special equipment or equipment not available to more than 40% of the mines were called Part 2 and this would have to be done by the individual mines for their own benefit at a later stage.

The first problem was now to train module writers to write modules about those items selected in such a way that it could be understood by those it was meant for. Also because of the practical nature of this system, it was not only the theory part that had to be described but also the practical side. By this is meant the "hands on" or practical side of the module where the participant would have to demonstrate his practical knowledge of the subject or equipment by doing it in practice.

Line people like selected foremen and artisans had thus to assist in drawing-up the course content of each of the selected items as each module had to be job orientated. Each module had to be edited by a committee and in the beginning some modules had to be completely rewritten.

The process of developing of a module can be outlined as follows:



This appears to be a very simple and straightforward process but experience has proved that unless properly managed it can become very complicated, costly and totally unproductive.

During a series of meetings and possibly a Workshop, a document is developed to assist the module writer with the content of the module. As was said in the beginning the modular system was adopted to eliminate the logistics problem of holding formal courses and provides valuable flexibility in application.

The C R I or learner Controlled Instruction System followed as a logical refinement and a high level of skill in module writing in this specific technique has since been developed within the Gold and Uranium Division. Numerous time saving refinements have been developed as a result of the growing skills available. The personnel involved in the programme are far along the learning curve and the work ahead will be done far more economically.

## 6.5 PLANNING AND INTRODUCTION

The main objective of this new system of modular training was to enable the artisan to improve and secure his own position for:

- a. Own security against Black advancement
- b. Improvement and own advancement
- c. Productivity.

However, management appreciated the fact that unless this artisans' foreman or supervisor was exposed to the same programme problems were foreseen.

Due to the high standard and work content of these modules the foreman could see a danger for himself and thus "block" the artisan. Alternatively a negative approach from senior management was a sure way of killing the system.

It was thus decided to plan the programme such that all the foremen had to write the modules first.

To encourage the artisans in the critical stages to start writing the modules, an amount of R10,00 was paid for each module passed. It was voluntarily, and although he could write the module examination in company time, he had to study in his own time.

The same condition applied to the foremen, although management had this compulsory for the foremen and for that reason they could take off to study the modules but in that case would not be paid. The foremen also had to do the modules before the artisans were allowed to follow.

## 6.6 A STRANGE COINCIDENCE PROVIDING A SOLUTION TO A MAJOR PROBLEM

- 6.6.1 As early as 1975 the Industrial Relations objectives of the group was set towards providing a modular system of training for artisans as a method and means of security and advancement. This system only came off the ground during March 1982.
- 6.6.2 As a result of a change in the Apprenticeship Act which effectively reduced the training of apprentices from 5 years to 3 years during 1978, the Chamber of Mines Training Committee decided to try out a CRI system for technical training and produced the first set of draft modules early in 1981.
- 6.6.3 This statutory reduction of the effective apprentice training time which can be clearly seen in the short period allowed for the practical training as per Chapter 5, was starting to create major problems for production due to a general lack of experience and knowledge of a large number of the newly qualified artisans.

Due to an advanced method of training the apprentices, a larger number started to pass their trade tests after 2<sup>1</sup>/<sub>2</sub> years with an even reduced amount of practical experience relevant to their job requirements for post apprenticeship.

## 6.7 THE SOLUTION

Up to a short while ago, this problem seemed to be unsurmountable on the sort term but we are now confident that we have the solution in our hands.

The coincidence development of practical modules for competent artisans in general, with the main objective to provide them with these modules as a safe-guard against black advancement and possible further advancement in case promotional opportunities would arise have been identified to be used for something it was never thought of originally.

These modules are now going to be used on a planned basis as the ideal training media for apprentices who have done their basic training in the Apprentice Training Centre and have to complete a programme of practical training in the underground section, in the Plant and the Workshops.

Since the CRI system was introduced in the Apprentice Training Centres, the apprentices could be trained on such a basis that they could be tested on a modular basis and trained on a systematic way.

However, the minute they left the Training Centre for their "on the job" training, there was little or no control and no measurement of performance and training.

The EDP programme is now available for advanced training in those aspects where they are sent for their practical training.

Although we do not specialize too soon in training apprentices, the system of EDP allows a young man to be trained and tested in different aspects of the practical side on different types of equipment.

As part of our long-term Manpower Planning Programme we specifically train for certain jobs or job categories. So, whilst the apprentice is still in his training, he could be sent to that area or equipment where management has needs.

He could then be given the necessary training there and tested as well.

By means of the EDP testing system which is modular and based on the CRI system as well, he can be measured and his competency determined.

Once he passed his trade test or completed his indentures due to time effluxion he could be placed at an area where he has proven competency.

Alternatively, if he arrives at a work area where he had not worked before, he could be checked by means of the system whether he has the competency to do the work. If he has not had the experience he could be retrained in the relatively short period while doing those jobs which he had not previously displayed sufficient knowledge on and then tested for competency.

We have thus managed to develop two systems which happen to be complementary because they are based on the same principles.

To a certain extent by coincidence the EDP system was developed at a time which slotted in ideally with the development of the Apprentice Training System.

A major advantage used in a modular system of training used in the EDP is that it identifies knowledge which employees already have and so obviates retraining in these areas.

#### 6.8 ADDITIONAL ADVANTAGES OF THIS MODULAR TRAINING SYSTEM

Although the original EDP was aimed at the interface between Black and White, there is no reason why the same concepts may not be used at higher and lower levels. It could be used with the same amount of success at the higher management than the low operator or operative level.

Out of a modular set of training material one could select any "package" at any level required.

## 6.9 ADVANCED COMPETENCY TRAINING

According to the unions all people are equal. Therefore we find the anomaly in our closed-shop wage agreements that once an apprentice qualifies as an artisan the basic starting rate for all is the same.

The fact that the one apprentice earned up to R80,00 per month more as recognition of his technical competence by obtaining a T4 or N6 does not mean a thing.

But, are all people equal? Different persons have received different talents. This we all accept. However, does our present training system acknowledge that?

Let us go back to our public schools. In earlier years there was no provision made for the above-intellectual pupil. The conventional system catered for the "average" pupil, thereby losing the slower pupil and frustrating the more intelligent one.

In time gone by, provision was firstly made for the below-average intelligent pupil by firstly providing special classes for them, and later on even special schools.

At a much later date only was provision made for the above-intelligent pupil to cater for his needs. These schools are still very few and far-between so a lot of frustration is still experienced in many schools because of the conventional method of teaching as described earlier.

Due to the fact that apprentices and artisans emerge from all walks of life, we all know that you will find the lesser or more intelligent ones. So, in their training and later work, there must obviously be the lesser or more intelligent ones. This should give you a lesser or more competent type of artisan - therefore all men are not equal despite what the unions say.

This specific problem was very well described in two different publications where the problems and frustrations of different levels of artisans was described and also the problem experienced with this difference in people.

We refer to the following two scripts by two students as part of the MA qualifications.

- a. CEG Labuschagne - 1961
- b. PA Gouws - 1980.

Due to the current union and closed-shop agreements as well as limiting statutory agreements we tend to find a low productivity among our skilled artisans as there is generally very little incentive for the better ones and ultimately the pace is set by the slower ones.

Under the modular system of training each apprentice can now work at his own pace. If we look back at Chapter 5, we seen that the allowed time in the divisional training centre in the first year is 12 weeks. That is the time that the selected apprentices are expected to do it in - for all practical purposes the maximum allowed time.

However, because of the CRI based system the individual apprentice works at his own speed. Some could thus complete that portion of the work in say 8 weeks. Once he has successfully completed that portion he may now move on. That is why some youngsters could complete and pass their trade tests after  $2\frac{1}{2}$  years.

Contrary to the conventional schooling method of teaching, there can thus be NO frustration for the above-intelligent youngster as he could move at his own speed and time. Similarly, the slower worker moves at his own speed. Due to the stringent selection criteria there is obviously a cut-off point below which persons do not make the grade and are thus taken out of the system.

Can this new EDP or modular training system

- a. identify a competent artisan under the present statutory system?
- b. distinguish between a more or less competently trained artisan?
- c. provide a fair system of total enumeration for the different levels of productivity which could be associated with the competency difference in artisans?

As was indicated in Chapter 5, there are currently mainly 3 ways in which a man could obtain artisan status in terms of the closed-shop agreement - with no measurable system of proving his competency as an artisan. After 10 years he could have on his record sheet 10 years of service, or in real terms of experience, 1 years experience 10 times over.

## 6.10 THE ARTISAN GRADING SYSTEM

As a summary to this script we will now describe a system which will be used:

- To identify, select and train apprentices to a level which would allow them to successfully pass their trade test in both the practical and theory.
- Thereafter, by making use of the same principles as above, only adding some extras in the form of the well-known Patterson Grading System (Patterson CH 1956) provides a means and method to answer the 3 questions asked.

But for for clarity we will first give a short overview of the Patterson System to ensure an easier understanding of the grading system.

### 6.10.1 The Patterson Job Grading Plan

The Patterson method is based on an analysis of work and tasks to determine what kind of decisions are made by employees. In any organisation six kinds of decision making can be identified. These six kinds of decisions are at six different levels in the organisation. The specific position of a job in the organisation is determined by the kind of decisions that have to be made that is critical to that job.

The six decision levels or bands are as follows:

- Band F - Policy Making Decisions  
Decisions framing policy are regarded as being superior to any other decisions. The levels are very wide and in many cases are only specified by the laws of the land.
- Band E - Programming Decisions  
Within the limits set by policy the execution is broadly planned or programmed.

- Band D - Interpretive Decisions

The limits of the interpretive decisions are set by the programme, plan or budget. The interpretive aspect comes from the choice of a best decision out of a spectrum of possible decisions, the limits of the spectrum being set by the programme. These decisions often involve determining the best use of available manpower and machines to achieve the targets agreed in the programme.

- Band C - Routine Decisions

The rule having been set by the interpretive decisions, execution begins. What is to be done has already been decided and the next level of decision - routine - is the choice of the way in which it is to be carried out. People taking these decisions can decide which process to use, they know the operations, what to do, where to do it and when.

- Band B - Automatic Decisions

This involves work in which the processes are defined and freedom of choice is restricted to the operations. Within the constraints of the processes, the "how" - the worker can decide the where, and when, he carries out the operations that constitute the process.

- Band A - Defined Decisions

The decisions made by the worker can be defined and the worker is left little choice other than variation in control of the elements of an operation.

The top three levels are management posts and all six levels can be related to terms generally used to indicate levels of seniority, ie.:

<u>BAND</u>	<u>KIND</u>	<u>TITLE</u>
F	Policy	Top Management
E	Programming	Senior Management
D	Interpretive	Middle Management
C	Routine	Skilled
B	Automatic	Semi-skilled
A	Defined	Unskilled

The grading of supervisors into the six bands is done by assessing first of all the highest level of decision making in non-supervisory tasks. Where this places the supervisor in the same band as those supervised it is necessary to separate the supervisor from the supervised by breaking the band into at least two job grades so that the supervisor can be in the higher grade, ie.:

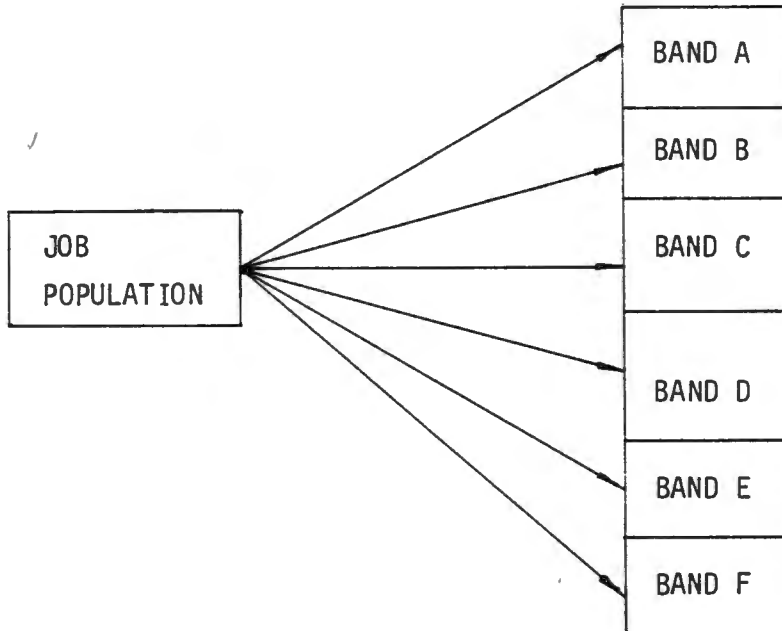
<u>BAND</u>	<u>KIND</u>	<u>TITLE</u>	<u>GRADE</u>	<u>KIND</u>
F	Policy	Top Management	10	Co-ordinating
			9	Policy
E	Programming	Senior Management	8	Co-ordinating
			7	Programming
D	Interpretive	Middle Management	6	Co-ordinating
			5	Interpretive
C	Routine	Skilled	4	Co-ordinating
			3	Routine
B	Automatic	Semi-skilled	2	Co-ordinating
			1	Automatic
A	Defined	Unskilled	0	Defined

#### 6.10.2 The Process of Job Grading

This first of all is necessary to compile a job description which describes all of the significant task carried out in sufficient detail to enable the Job Grading Committee to decide the Grade into which the job should be placed. Each job is then individually graded by the Committee on the following basis:

##### Establish the band

Each task is examined and , according to the type decision making involved, is given a Band ranking. The highest ranking obtained in a list of tasks decided in which bend the job will be placed.



The jobs are then sorted within the skill bands in terms of job group definitions into Job Groups.

BAND	NUMBER OF PERMISSABLE JOB GROUPS		
	<u>BAND</u>	<u>MINIMUM</u>	<u>MAXIMUM</u>
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px 5px; margin-right: 10px;">A</div> <div style="display: flex; flex-direction: column; gap: 5px;"> <div>A1</div> <div>A2</div> <div>A3</div> </div> </div>	A	1	3
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px 5px; margin-right: 10px;">B</div> <div style="display: flex; flex-direction: column; gap: 5px;"> <div>B1</div> <div>B2</div> <div>B3</div> <div>B4</div> </div> </div>	B	2	5
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px 5px; margin-right: 10px;">C</div> <div style="display: flex; flex-direction: column; gap: 5px;"> <div>C1</div> <div>C2</div> <div>C3</div> </div> </div>	C	2	5
D      D1 D2	D	2	2
E      E1 E      E2	E	2	2
F      F1 F      F2	F	2	2

### 6.10.3 Definitions of Bands

A job consists of one or more tasks. Tasks may be all at the same level or may be at different levels for skill bands. If all tasks in a job are at the same level there is no problem. The job is placed in the appropriate skill band. If there are tasks at different levels in a job, then that job is placed in a skill band in terms of the highest level task in the job provided it is an essential element of the job. It is important therefore that jobs should be broken down into tasks because it is the level of tasks which decides into which skill band the job will go.

In placing jobs into groups within the bands, consideration is given to the manner in which all the tasks performed by the worker inter relate to comprise a job.

According to the Patterson Grading System the artisan would fall in the skilled "C" Band. Let us see what this entails.

BAND C (Skilled)

DEFINITION OF SKILL BAND	JOB GROUP	JOB GROUP DEFINITION
At Band C level the worker is not only with tasks but also with processes. A process is an integrated combination of tasks which required an understanding by the worker of the way in which tasks have been combined before he can carry out the process at an acceptable standard. It often means that the worker must acquire qualifications or considerable experience which will ensure that he will understand the theoretical or systematic components and will operate successfully in terms of that understanding, when he is carrying out a process which requires either skill or judgement. It follows that since the process demands a knowledge of procedure, systems or theory, the worker is in a position to choose or to take decisions regarding which technique or routine he will follow once he has summed up what the requirements of the particular situation are.	C1	The choice of processes available to the worker is limited. At this stage has potential and aspirations but lacks a certain amount of experience.
	C2	The worker has a larger variety of processes available to choose from. Bulk of artisans will be in this category. These are the doers.
	C3	The worker has a large variety of processed available to choose from and is working to strike requirements, and the tolerance demanded are very much finer. The specialist artisan like turbine technicians and winder specialist
	C4	Co-ordinators of C3 workers. Tends to go more into the supervisory work and spends less time on the tools - the so-called working charge-hand.

A worker at this level is matching routines/techniques/procedures to changing circumstances.

The decisions taken are routine.

As we are not discussing supervisory levels, our artisan range will thus fall into C1 and C3, as C4 is co-ordinators of C3 workers which is supervisory.

## 6.11 REFERENCE CRITERIA FOR GRADING OF ARTISANS

### 6.11.1 Critical Objectives

To formulate an unbiased system/methodology for evaluating an artisans skill and competency in relation to others within the same trade.

### 6.11.2 System Prerequisite

A system to be devised which will be acceptable to all concerned which can/will be used as a common yardstick to measure/evaluate each artisans skill-level in relation to others within the same trade. The system must also be such that it will indeed provide management with an assessment of its employees which in turn will form the basis for selection/placement in accordance with the skills demand of various jobs. It should also be such that it will optimise labour and hence improve productivity.

#### a. System Methodology

The system must be such that it measures/evaluates/recognizes an artisan in respect of:

- his proficiency and dexterity on industry related equipment
- his trade theory knowledge as related to industry equipment and his trade as a whole
- his pure trade related technical qualification.

The proposed system is based on the summated weighing score obtained from 3 skills thermometers, ie.:

- Industry/Trade proficiency
- Industry/Trade Theory knowledge
- Technical qualifications.

The weighting factor allocated to the individual thermometer is debatable and may be modified. The principle is more important at this stage. Once it is accepted the rest will slot in.

See Annexure 1 for Thermometer Weighing System.

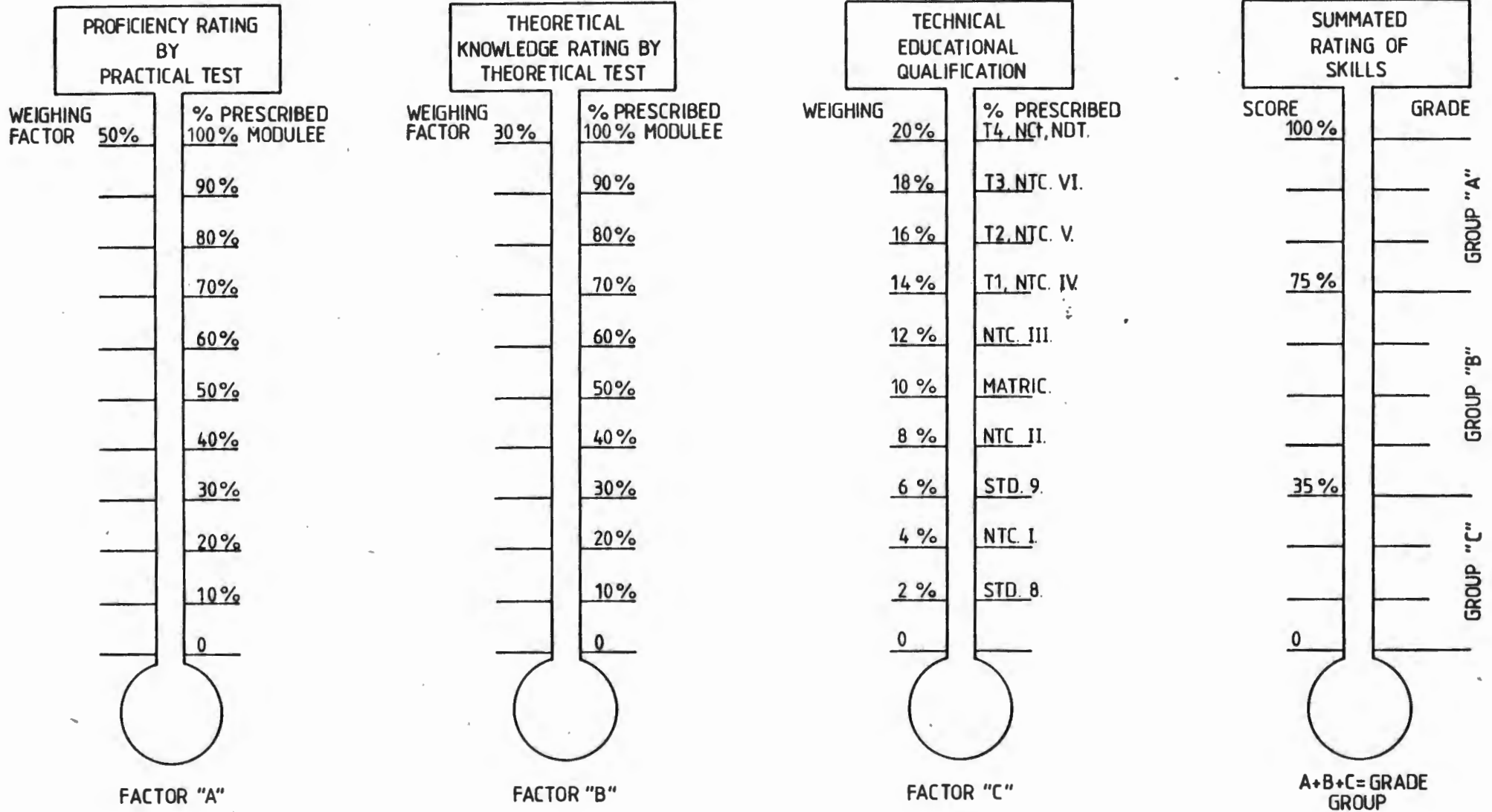
- b. If the above system of measuring/evaluating/recognizing of skills is accepted in "principle", then the next step in the realisation of a grading system is the provision of the measuring/quantifying criteria.

To this end it is proposed that in respect of criteria "A" and "B" above the following method be applied, ie.:

- A selected range of trade industry equipment related modules to be passed by an artisan within his trade. The range of modules need not all be passed by an artisan to become an "A" or "B" class artisan, however certain modules will be mandatory to qualify as a "B" or "A" class artisan, ie. prerequisite modules to enable upgrading to "B" and then additional prescribed modules for upgrading to "A" class artisan will be required.
- The prerequisite modules may constitute 15 - 30% of all the module content required to be upgraded and the balance could be made up by any of the remaining modules. Obviously for placement purposes, management will direct/lead artisans to pass modules applicable to their manning needs.
- Once having been upgraded to either a "B" or "A" class artisan, the artisan will be accepted as such throughout the mining industry (maybe outside industries as well). His record of modules passed will place the new employer in a position to place him ideally, ie. suited to job needs and/or the employer will subject the artisan to further training in those modules which are required by the job where the employer intends to place him.
- The modular training will be both "hands-on" as well as trade theory modules related to industry equipment, thus satisfying the criteria for thermometers "A" and "B" above.

- The modules will in effect each be a miniature trade test, and as such be a true measurement of the individuals proficiency and dexterity as well as his knowledge of the trade and equipment.
- c. The third thermometer will be based on National technical qualifications of the artisan.
- d. Annexure 2 indicates the principles outlined above.

### SKILL FACTOR GRADING SYSTEM FOR ARTISANS



<u>SALARY BAND</u>		<u>GRADING CRITERIA</u>	<u>GRADE BAND</u>
"X" RAND	* #	M.I.E.T.T.B. COURSE + C.O.T.T.S. TRADE TEST	C.
"Y" RAND		AS FOR "C" GRADE <u>PLUS</u> COMBINATION OF "A" + "B" SKILL FACTOR MODULES WHICH MUST INCLUDE THE PREREQUISITE TRADE AND INDUSTRY EQUIPMENT RELATED MODULES <u>PLUS</u> CREDIT FOR FACTOR "C"  THE SUMMATED SCORE FOR FACTORS A + B + C TO 35%	B.
"Z" RAND		AS FOR "C" GRADE <u>PLUS</u> COMBINATION OF "A" + "B" SKILL FACTOR MODLUES WHICH MUST INCLUDE THE PREREQUISITE TRADE AND INDUSTRY EQUIPMENT RELATED MODULES <u>PLUS</u> CREDIT FOR FACTOR "C"  THE SUMMATED SCORE OF FACTORS A + B + C TO 75%	A.

(\* Mining Industry Engineering Trades Training Board)

(# Central Organisation for Trade Testings Scheme)  
(described in Chapter 3)

## CONCLUSION

At present the economy of the country is still in a very depressed way and could remain like this for some time. We all know that in time to come we will move into an economic upswing again.

One of the major limiting factors in the past during an economic upswing used to be a shortage of "skilled labour". We would rather refer to this as "competently trained labour". By this we mean competently trained for the level it is operating at.

In this script we have tried to indicate that contrary to the situation 30 years ago, we have today at our disposal a newly developed modern training system based on the CRI principles. This system is designed on a modular basis, and provided the correct selection procedures are followed in the original selection, it may be used to train from the country's large untapped labour resources to a level of competency which is measurable in various area to meet certain set standards.

Due to certain statutory restrictions like closed-shop agreements and the Mines and Works Act which limits certain race groups to certain jobs and excludes others, this study was done on Whites only. Certain selection criteria and tests one on a limited scale did not indicate any difference or unfairness on other race groups. This confirmed certain similar studies done in the USA as indicated in Chapter 1.

We have described a system of modular training from a completely unskilled level like a first year apprentice to a highly competent Grade 3 artisan by means of a controlled system which could be measured at each interface. By taking this system and replacing with other parts in an intelligent and planned way, the combinations of modular systems are virtually unlimited.

We have thus described a modular training system which is at present bound and regulated by certain union and statutory systems. We are however confident that this same system has virtually got unlimited potential by making use of a process of selection education and training a wide range of required skills to a level of competency which was, up to this stage, not possible.

With our expected upswing on the economy, we will again be faced with a major skill shortage and unless we start in good time to select, educate and train not only our Whites, but also the other race groups, we are going to face a major crisis.

Although the result of the Wiehahn report removed certain legal restraints on training of other race groups, there are still a lot of restrictions and constraints. We will have to address these in good time to ensure that we have available the necessary human material for training as this could mean long term survival.

## BIBLIOGRAPHY

### A. BOOKS

1. BLOOM B.S.  
Handbook on Formative and Summative Evaluation of Student Learning  
New York : McGraw-Hill, 1978
2. DAVIES I.K.  
The Management of Learning  
London : McGraw-Hill, 1971
3. MAGER R.F.  
Preparing Instructional Objectives  
Belmont California : Fearon Publishers, 1975
4. MAGER R.F. and PIPER P.  
Criterion-Referenced Instruction Analysis, Design and Implementation  
Belmont California : Fearon Publishers, 1976
5. PATERSON T.T.  
Job Evaluation  
Business Books - Communica : Europe, 1978
6. TIFFIN J.  
Industrial Psychology (Third Edition)  
New York : Prentice Hall, 1952

### B. ARTICLES

STEYN G.

Competency Based Training Opens Path to Efficiency.  
Coal, Gold and Base Minerals of Southern Africa, May 1980