A QUANTITATIVE MODEL FOR ASSESSMENT OF VOCATIONAL SKILLS.

BY

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THESIS

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This is certified that this work has been done by me and that it had not been submitted anywhere for award of any Degree or Diploma or for publication.

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ABSTRACT

It is universally accepted that education improves the quality of manpower available for employment.Trained and educated manpower can make the best possible use of resources available. But due to financial constraints and low gross national product level, developing countries are not able to finance formal schooling to most of its people. A practical alternative that have often been suggested to overcome the shortage of trained and educated manpower is to harness and reinforce the non-formal methods of learning and skill development.

Non-formal vocational learning is inexpensive, largely self supporting and combines education with production and training. A large number of school dropouts enter this sector in search of livelihood and acquire skills and competencies as a by-product of doing productive work. A radical rethinking of how to bring about qualitative changes in the vocational learning process can be seen in recent years. Many essential elements of what could be called a new approach to training and skill development have been identified. The reprocessing of school dropouts have also gained considerable attention and efforts to bring them in the national skill structure have been worked out.

The basic premise of this stndy is that, the natnre of the new approach demands a corresponding new approach to testing and evaluation of these skills, for their reinforcement and proper utilization. In this study a quantitative method for measurement and evaluation of knowledge and skills have been proposed. The method will be specially suitable for appriasal of individuals who have acquired their skills outside the formal learning system. This can be an alternative as well as a complimentary method to the present examination system and will serve quite well with the newly introduced National Skill Standards in Bangladesh.

CONTENTS

1.0 INTRODUCTION

Most nations today are development minded. The less developed countries which have been poor and stagnant for centuries are in a state of revolt against poverty, disease, ignorance and dominance. The advanced countries likewise are committed to growth and the more rapid and spectacular, the better.

The building up of a modern nation depends upon the development of its people and the organisation of human activities. Human resource development (HRD) is the process of increasing the skills and the capabilities of all the people in the society. In social and cultural point of view, the development of human resources helps people to lead fuller and richer lives, less bound by tradition. In short, the process of HRD unlocks the door to modernisation. Limited development of human skills, mainly due to poor education and lack of training 'leads to underutilization of their intellect, faculties and potentials and result`s in lack of optimism. Generally speaking, the basic problems of most underdeveloped countries are not so much due to poverty of natural resources as to the underdevelopment of their human potentials.

The first task in such a soceity is to build up its human capital, which implies improvement in education and the mental and physical health of its people. But proper education must be accompanied by adequate outlets for the knowledge and training thus acquired. Any educational programme, where technical training is imparted to the youth, may become complicated and a source of social distortion, if proper outlets for the trainees are not provided. In rural areas, those, who have higher education and improved technological skills, become misfits to the rural economic activities and prefer to migrate to the urban areas. Obviously an educational system of this kind can neither encourage mass utilization of newer technologies, to activate development nor can it arouse among the young, a respect for the soceity in which they have been brought up.

Institutes of Technologies and the Engineering University prepares and traines, respectively midlevel and higher level technologists and engineers. The Bangladesh National Council for Skill Development and Training has proposed a vertical move-up scheme for skilled craftsman which is presented in Figure - 1.

Under the above system school dropouts and school leavers can take either a formal institution based training or learn their skill on the job in an industrial establishment. The first stage can lead to a semi-skill level certificate. In the second stage further development can take place either way leading to a full- skill level certificate. It can be observed that apart from a formal institutionalised schooling system, another route of skill development has been recognised. A great number of skilled worker generates through this route and form the majority of skilled workers in most countries. They are produced " on the job " in the informal sector, like apprenticeship, either in the traditional workshop household or the semi-traditional small wayside workshops. Even in the modern industrial sector, it is probably true, that learning at the enterprise level constitutes a very large proportion of the total skills and competencies acquired by the workers.

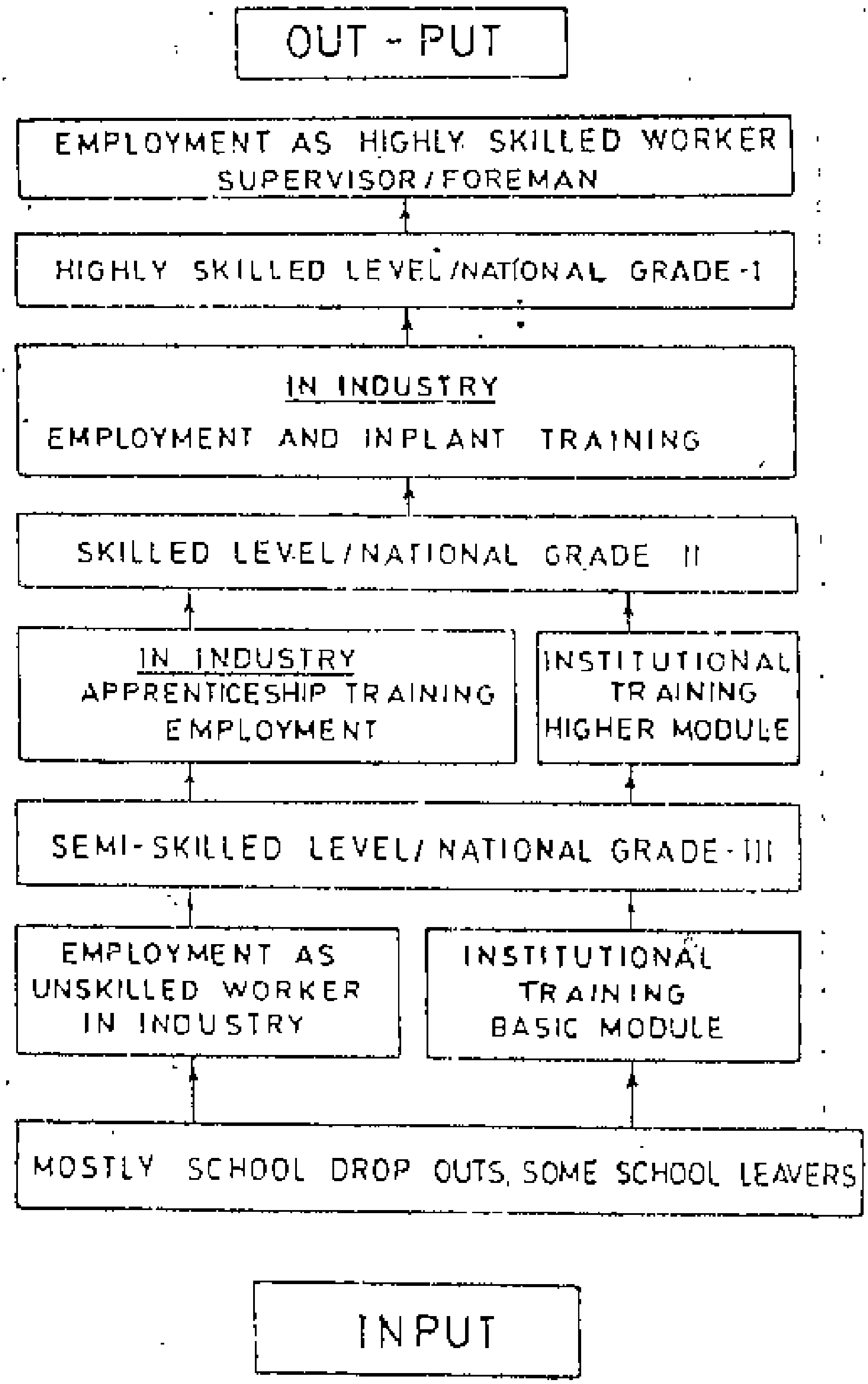
Efforts to quality these manpower will have a favourable impact on the development effort of any country. NCSDT has already approved National Skill Standards for the three levels of 13 trades, while some others are in process. A scientific method of grading and evaluation along with the standards will go a long way in meeting the long felt need of the innumerable craftsmen, specially those who acquire their skills outside the formal learning system. Any such testing should be based on the knowledge, aptitude and productive skills of the workers. As this will provide positive incentive to upgrade his job position, which in turn will result in better pay, the workers would perhaps see the way of improving their knowledge base as well as skills and confidence. A sense of self respect will generate and healthy competition might arise, consequently vertical job loading based on skill requirement will be possible. The national economy will also be benefited with better productivity and work quality.

For a developing country like ours, greater need is for manpower engaged in adaptive technology than in fundamental research. The vast majority of humanity in these countries live in traditional and semi-traditional societies. Problems relating to the improvement of their socio-economic conditions cannot be resolved satisfactorily within the precint of scientific and academic institutions. The challenge is acute and intricate. The vast majority of the people have little access to formal technical education. The need for evaluation and recognition of the non-formal method of learning thus cannot be ignored. The linking up of learning with productive activity have been found to foster self-reliance and faster indigenisation of technology in many societies.

Two world wars and intermittent period of prosperity emphasized the need for systematic means of training for job skills. For efficient running of industries, workshops and modern farms, a stream of well trained, skilled and educated manpower was urgently required. Thus an analytical approach to training people in different, skills at a short time was born. This training takes places in formal institutions under the guidance of professional instructors. The trainees are qualified through tests and examinations and a formal certificate is awarded after successful completion. On the other hand informal training is age old and takes place in real life workplace as a by-product of production. In early times these skills developed from the needs of mankind to sustain and defend himself in an unkind environment. The skills usually passed from father to son and near relatives, but as soceity advanced and demands for goods increased, the skilled craftsmen started taking apprentices, to help him. Those apprentices gradually learnt the trade by picking whatever they could from their peer and follow apprentices. The system exists still today in the traditional workshops and farms of many countries.

In Bangladesh, as in other developing countries there exists a formal system of educating and training technical manpower. The National Council for Skill Development & Training is the apex organisation for guiding the development of base level skilled manpower in Bangladesh, while the Polytechnic Institutes,

FIG-1 : NCSDT SCHEME FOR SKILL DEVELOPMENT



2.0 OBJECTIVES OF THE STUDY

The adequate supply and distribution of skilled manpower in the national economy is a basic ingredient to its viability and more specifically in improving its technological base. This supply can come from two sources, the formal institutional education process and the informal "on-the-job" learning process.

Presently formal learning system is not producing a proper mix as well as sufficient manpower in Bangladesh, and in many other developing countries. As a result various sector of the economy fall short of the right number and combination of manpower needed for development, while some other sectors generate jobless literates. On one hand, due to paucity of resources, proper educational facilities cannot be provided to the people, on the other hand, there is considerable wastages of available resources, in various ways. Wastage due to stagnation and dropouts accounts for the larger proportion of education losses. The students who cross the hurdle of examination with some years of failure give rise to stagnation and those students who dropout of the course without completing it, give rise to wastage due to dropout. Another group, who does not utilizes its training give rise to another component of wastages. Informal learning on the other hand is generally in gear with the limited technological need of the productive sector of a country. The interaction of man and machines results in better utilization of available technology and human resources. The generation of the type and numbers of skilled hands are influenced by the socio-economic factors of the country.

It is often difficult at an early stage of economic development to predict manpower needs. Moreover there is today a fast race between innovation and obsolescence due to exponential growth of technology. Human intellectual potential will be greatly wasted if a promising youngman is prepared for a job that might not exist in the future.

Time has come to give some positive thoughts on the nonformal method of learning in the country. The informal doing-based learning is inexpensive, largely self supporting and instrumental in acquiring technological capability of a nation. At some stage of economic development it is a necessity to maintain progress, a mechanism to get release from technological dependency. The example of " Dholai Khal" industrial enterprises is a glaring one . But the prevalent general view that formal education gives recognition and status, have led to frustation and lack of opportunities for the skilled hand, that emerge from the informal sector. The recruitment policies of large scale and public sector organisations, based on educational selectivity are other deterent. Job specification there, quite often requires qualification partly in emulation of advanced countries and partly because the educational system is over providing.

This study is proposed to deal with knowledge and vocational skill acquisition of the human inputs in the nonformal learning sector. A " Knowledge Index " is proposed to be devised based on scientific techniques of evaluation and rating to serve as an useful method to qualify the skilled craftsmen. The importance of the scale lies in its wide potential to provide a desperately needed testing and evaluation method to suit a large number of craftsmen of various background and discipline, specially those who did not have access to formal instituion based training.

3.0. LITERATURE REVIEW

3.1 NONFORMAL SKILL LEARNING

Present knowledge about the different aspect of informal learning is not adequate. The learning routines and environment that exist in this sector have not been systematically explored. Specially in the country, there had been little efforts to find the relationship that exists between learning and productive activities.

Harbison and Myers (1) have pointed out that in the developing countries " there are many kinds of institutions for on-the-job training of manpower, for eliminating illiteracy among adults and for community development. But with the exception of China, they are given much less attention than they deserve and in many cases their potentialities have hardly been discovered, let alone exploited."

In China, education is far more than schooling. It means continuous indoctrination, propaganda, skill development and agitation. And the policy has been to stress not only work with education but also education with work. The Chinese rulers have described their philosophy as applied to education in the following terms (2) :

"We have put into effect a programme with equal emphasis on schools operated by the state and those operated by factories, mines, governmental organs, enterprises, civil bodies, armed forces, peoples communes, cities and street organisations; on full time, part time and spare-time education; on school education and self education, and on tution free and tution paying education "

It is difficult to evaluate the success of this drive, to place training responsibility on employing organisations and civic bodies but it does give clear indication that the Chinese are placing major emphasis on the upgrading of employed and adult manpower in their broad stategy for human resources development.

On the job training has also spread widely in many other countries in East Europe, Latin America and South Asia. In Columbia, for example SENA (Services National de

Aprendizise) has developed an outstanding programme of aprenticeship training, night courses for adult workers. The SENA organisation in controlled by the Ministry of Education and are financed by prospective employing organisations, with the result that its activities are closely geared to `the needs of the factories, which are taxed for its services.

Even in advanced countries like United States, there has been a lot of debates on the benefits and efficiency of on-the-job learning. David (3) writes "Vocational Education is built on the premise that the student learns best by doing, by exercising the skills he needs, under the same conditions he will encounter in a real job. At best therefore there are many skills that cannot be taught as well in a school shop as in a well organised on-th-job learning programme"

In India, there had been considerable indepth studies on non-formal method of education, several works has been done to find the interrelationship between different input and output factors of education and ways and means to reduce wastages. In a seminar organised in 1976, it was urged that urgent steps should be taken to check immigration of village artisan to urban areas in quest of other jobs, which is causing rural brain drain. The present sleepy village primary shools, which have a large wastage rate in terms of droupouts and efficiency in content learning should be reorganised as non-formal vocational education centres.

Coombs and Ahmed (4) have defined " non-formal education as an organised systematic educational activity carried on, outside the frame-work ot the formal school system to provide selected types of learning situation to particular subject groups in the population, adult as well as children". They have shown that non formal education can include within school programmes such areas as agriculture extension, community development, farming, technical and vocational training etc. They maintain that non-formal education transmits new skills and values effectively and economically and now is a practical popular alternative.

In the country study series on "Technology Policies and Planning," Mahmud (5) has given some details about the state of craftsman training in Bangladesh. The craftsman training programme in Bangladesh is supervised by the National Council for Skill Development & Training. The Bureau of Manpower Employment & Training (BMET) and the Directorate of Technical Education (DTE) are responsible for conducting the formal courses. Apart from the formal courses, non-formal training are also organised by various ministries and non-governmental organisations, who utilize facilities available in different institutions and industries. In the industry based training programme, short-term in plant training is provided. For facilitating on-the-job industry- based training an 'Apprentice Ordinance' was promulgated in 1962. So far 27 trades have been declared apprenticable and 79 trades have been brought under the ordinance. As reported in a recent publication of BMET (6), the ordinance is under revision to broaden the scope and coverage and make it more flexible and respondent to the requirement of the present time. The revised apprenticeship programme is expected to provide a comprehensive scheme for training within the facilities available in industries.

The formal training courses conducted by BMET and DTE are of two years duration, divided into two separate independent parts i.e. Ist year and 2nd year. Each part consists of nine months of institutional training and three months of industrial attachment. First year contents meet the requirements of National Skill Standard (Grade III) i.e. semi-skill level. The trainees on completion of the first year course may go for employment or if they so desire may also continue through the second year course to meet the requirements of the full skill (National Grade II) level. The Bangladesh Technical Education Board is responsible for conducting National Skill Standard test for grade - III and grade - II and for issuance of necessary certificates.

Any skilled worker can apply for appropriate trade test for skill certificate even without attending the formal training courses. BMET conducts evening trade courses for those workers to refresh their technical knowledge prior to the test and for those who are employed and cannot avail the regular day courses.

3.2 MEASUREMENT OF EDUCATIONAL ACHIEVEMENT

A good number of literature can be found on measurement of educational achievement. Much work in this respect has been done in the United States and other advanced countries and in India. A number of methods have been developed to evaluate the aptitude and achievement of individuals, yet the problem of grading a persons achievement has always been difficult and troublesome and remains till today. Some experts believe that it is even more complex and difficult than the problem of building a good test and using it. In an early classic on educational measurement. Thorndike (7) explained some of the reasons, why educational achievement often is difficult to measure. He writes :

" Measurement which involve human capacities and acts are subject to special difficulties due chiefly to.

a) The absense or imperfection of units in which to measure.

b) The lack of consistancy, in the facts to be measured, and

c) The extreme complexity of the measurements to be made."

Marks or grades are, of course, measurements of educational achievement assigned on the basis of some scale. But marking system requires evaluators, whose natural instincts often determine their judgement. It has been found that quite often similar responses are graded differently by different judges. Variability in marking standards and practices has been investigated by many researchers. Travers and Gronhund (8), for example found wide differences of opinion among members of a faculty on what various marks, should mean, and the standards and weightages that should be followed in assigning them. Thus an accurate unit of measurement that can be uniformly followed needs to be evolved.

Ebel (9) writes that, publishers of standardised tests of educational achievement and directors of wide-scaled testing programes which use achievement tests face a special problem in deciding what to test. What is the consistancy in the elements that are to be measured. What about the outcomes of education that are essentially qualitative rather than quantitative. Is it reasonable to expect that these qualitative outcomes can be measured ? The weight of a man, his age, his bank account, can be taken as quantities while his health, his honesty, his ability to do certain job, his understanding of a problem as qualities. But it is also possible to regard all of them as quantities. And if they serve to differentiate him from other men, because he exhibits more or less of them than other men, they become quantitative qualities.

Thorndike (10) defended the measurability of human traits by arguing that " whatever exists at all, exists in some amount." And McCall (11) has added that "Anything that exists in amount can be measured."

Then comes the problem of how to measure ? the most commonly used types are the discussion type, the objective type and the mathematical problem type of tests. Relative to objective tests, both discussion type and problem type tests are easier to prepare. But objective tests can be scored more rapidly and more reliably, than the other types. The most commonly used types of complety objective tests items are mutiple choice, true false , matching, and classification. Many other types has been deserved in comprehensive catalogs (12).

Thorndike (13) writes. " We have faith that whatever people now measure crudely by mere descriptive words, helped out by comparative and superlative forms, can be measured more precisely and conveniently if ingenuity and labour are set at the task. We have faith also that the objective products produced, rather than the inner condition of the person whence they spring, are the proper point of attack for the measurer at least in our day and generation. "

Davis (14) writes that, "The construction of solid and reliable tests require consideration of quantitative information regarding the difficulty and disemminating power of each test exercise or item, that is proposed for use". Such information can be provided if we identify every item in details and analyse them against every other and determine proper weightages between them.

Ciardi (15) writes,

"Having written three words, the poet must choose a fourth. It doesnot just happen, it must be chosen. And having written the fourth he must choose a fifth. And so on for all the elements of the poem - every image, every metric emphasis, every last comma must be selected for admission. The good poet is defined by the quality of the choices he makes - by the exactness of his demands, and by the rigidity of his refusal to make cheap choices".

In fine, the necessity of measuring achievement and skillness of an individual engaged in a certain vocation can be summarised in the following words by Nathan (16),

" We must never forget that to the degree that we are able to measure medical competance, to just that same degree will medical competance be available to our people"

The literature scanned, indicate the necessity and possibility of devising a scientific method of measuring educational achievement. So far, no comprehensive work in this respect has been taken in the country, specially in the field of vocational learning. The present study attempts to review and discuss some theories related to such measurements and to formulate a method for evaluating achievement of vocational skill learning.

4.0 DEVELOPMENT OF THE GENERALISED MODEL

In an attempt to formulate a model to measure the quality of educational achievement a number of characteristics are relevant. To start with, it is desirable to define the problem area and then proceed to find the different tools and techniques of measurement, currently available. Later on it might be possible to sort out the various ideas and integrate them.

4.1 DEFINING THE PROBLEM AREA

4.1.1 Knowledge

As defined in Webster New Collegiate Dictionary (17) "Knowledge" is :

a) Familiarity gained by actual experience.

b) Acquiantance with facts, hence, scope of information.

c) The act or state of understanding, or cognition.

d) That, which is gained and preserved by knowing, enlightment, learning.

This definition suggests the scope of the concept of knowledge, and its relationship to or identity with experience, fact, information, understanding, enlightment, and learning. Phychologists suggest that what a person has experienced or learned is never completely forgotten. It all remains somewhere, however deeply burried and overlaid with other learning and experiences. Not all of the items in this store of knowledge are of equal value. Some are of limited, temporary interest, some are indefinite and inaccurate. One of the most important and most difficult tasks of analysis is to sort out the more valuable ones from the less valuable. It is easy to say, that those items of knowledge which are most widely useful or most central to the performances of a craftsman should be regarded as most useful in formulating a composite measure of their knowledge and skills.

The second major problem is to find the person's level of command of the knowledge. To have command of knowledge is to have ready access to it and full comprehension of its scope, its limitations and its implications. It can be called: substantive knowledge. Substantive knowledge encompass understanding and ability to explain, ability to relate the different facts, concepts and principles involved, and the ability to work them out.

4.1.2 Learning

There are a variety of definitions of learning, each one of them highlighting one or more aspects of learning activity. According to Sheal (18), theorists however tend to agree that learning involves,

a) An active process of participation, where learners participate and are actively involved.

b) A relatively permanent change in behavior. Gague (19) writes, " the change may be and often is an increased capacity for some kind of performance."

c) The acquisition of additional information, skills or attitudes. The additional element produces the change in performance.

Kidd (20) writes " learning results in certain kinds of change, the most common being the committing to memory of facts, the acquiring or improvement of a skill or process, the development of a changed attitude". Learning may be conscious or unconscious. It may be structured and formal or incidental and informal. But everything a person has learnt as a result of pereption of his external environment or as a result of his internal reflections or thought process, becomes part of his knowledge system.

4.1.3 Individual learning Styles

Not everyone learns in the same way and each individual has his or her own preferred style of learning, Kolb(21) has identified four important dimensions of learning styles.

a) Reflective observation
b) Abstract conceptualization
c) Active experimentation
d) Concrete experience.

Reflective observation is the preferred style of those learners who rely heavily on careful observation, and learn best from situations that allow impartial observation. The key word for this style is 'watching'.

Abstract conceptualization is the preferred style of those learners who have an analytical and conceptual approach to learning and rely heavily on logical thinking and rational evaluation. They learn best from theory and integrate new learning with, what is already known. The key word for this style is ' thinking.'

Active experimentation, which involves trial and error discovery methods, is often preferred by learners with mechanical and scientific interests. The key word for these learners is 'doing'.

Concrete experience is the preferred style of learners who have an experience based approach to learning. They learn best from specific examples and involvement. The key word here is 'feeling'.

Previous knowledge and experience have considerable influence in the learning process, especially of an adult. Adults have a rich store of knowledge and experince to which to relate new information. New learning tends to take on more meanings as adults are able to relate it to their past experience. Buzan (22) comments.

" As memory is a process which is based on linking and association, the fewer items there are in the recall store, the less the possibility for new items to be registered and connected."

4.1.4 Craft learning.

In common concept, it is the process by which an individual becomes good with his ' head' and 'hand'. The process involves watching, thinking, doing and feeling - all the styles of individual learning. As explained by Roger (23), 'Learning takes place when adults come into direct confrontation with problem". A good craftsman learns first by watching and understanding the particular form of technology. Secondly he tries to acquire the more general principles and theories involved and integrates them with his observation. This allows growth of perception and reasoning of wider applications of these principles. Third increased practice enhances the capacity and confidence in manipulating and experimenting with the technology. Which in turn generates creative feelings and outlook to find alternative ways and means to modify the work mode. When sufficient time is provided for the assimilation of new information, practise of new skills or development of new attitudes learning can occur without anxiety and confusion.

4.1.5. Problem of Measurement

In the context of this thesis, the basic task is to find ways and means to measure the outcome of craft learning, particularly the non-formal learning activity. The first problem that arises is to determine what to measure, the second is to decide how to measure. How well the first problem can be resolved will largely determine the 'relevance' of the test. To resolve the second problem the relevant factors in the activity have to be assessed and the essentially qualitative and the quantititive outcomes of the process isolated. Then comes the search for finding suitable methods to qualify these qualititive outcomes of learning. By quantification it is meant discovering ways of getting numbers attached to examples of the quality so that differences in the number correspond atleast roughly to the perceived differences in the quality.

A description of the process of quantifying a characteristic constitutes what some scientist call an "operational definition" of it.Often such characteristics start out as rather vague concepts, based on hunches or hypothesis. The process of devising a method of measurement however forces and results in a very specific definiton of the thing to be measured. The details of the 'learning by doing' process are almost unobservable except by the most painstaking investigation. Some of the affects are subtle and wholly unforeseen, which may not become apparent untill after long period of experience.

An experienced craftsman knows all the practical operations which make up his activity, but he is often not able to explain, why in this particular situation he uses these operations and in another situation some others. He answers, "I feel it". In fact, this feeling is nothing, other than the result of performance of a series of operations, directed at isolating the definite attributes of a situation. But the craftsman is not aware of this cognitive part of his activity and therefore is not able to give an account of the cognitive operations involved in doing the task. These elements are the accumulated knowledge of science and technology of which he is not fully aware.The other dimension of his activity often called psychomotor skills, of which he is fully aware is the application of his knowledge to practical tasks. The application of this knowledge obviously involves perception and thinking and growth of experimental and creative attitude. While trying to formulate a model to test a craftsman's performance these elements should be ignored.

At the preliminary investigation, therefore all possible relevant variables, should be included.At the analysis stage it will be possible to need out and ignore those varvates whose contribution in the actual job performance is negligible or correlates with other variables. From the above discussion, we may inter that in order to assess affactively the following characteristics needs to be evaluated.

a) His Theoretical knowhow i.e knowledge of science and the technology of his spaecific trade.

b) His Practical ability i.e his ability to use the knowledge to practical task.

c) Latent effects of Skills i.e his adaptive and creative abilities .

The three set of variates however donot exhaust the character of learning, but can only provide us with an oppurtunity to order, classify, group and interpret the major elements of the learning process. As most of the factors involved have a qualitative outcome, the basic problem in documenting them is to reduce measurements and observations to a number of variables that can be

quantified and interpreted into a simpler form which conveys necessary meanings. The mathematical term of the system is known as " indexing".

For constructing the composite index appropriate quantitative values have to be assigned to the variables and elements thereof and proper weightages determined between them by using suitable mathematical techniques. One may proceed eiher by combining all the variables in one particular set of variables into a "composite index" for that set and then combine the indices of all the different sets into a final index. Or one may take them all together to build up the final index straight away.

4.2 MEASURING TECHNIQUES

Measurements covers a wide range of activities. The only thing they have in common is the use of numbers. The most general definition of measurement means assignment of numerals according to rules. As the term is going to be used in this text, a measurement of educational achievement is a quantitative description of what a learner has achieved. A measurement of such achievement has to be :

a) objective i.e. free from unique biases of the particular judge and

b) reliable, i.e. free from errors of measurement.

In principle all achievement or outcomes of a learning process are measurable. They may not be measurable with tests currently available. But if these outcomes can be identified as important for a persons vocation, then they must be measurable. To be important an outcome of learning must make an observable difference. That is at some time, under some circumstances, a person who has more of it must behave differently from a person, who has less of it. For all measurements require a verifiable observation of a more less relationship. Some of the theories, related to measurements of learning are discussed below :

4.2.1 IDENTIFICATION OF FACTORS

Identification of impact factors is an important feature of any assesment. It can grow only from a thorough description of the environmental conditions, socio-economical as and politico-legal etc.

Impact identification are of two basic types viz

a) Scanning techniques

b) Tracing techniques.

In addition to the above two basic types some methods combine characteristics of both scanning and tracing methods : Morphological analysis is one. Although morphological analysis was designed to provide an exhaustive search using scanning technique, it nevertheless assumed a field of structurally related elements as in tracing method.

4.2.1.1 Scanning Techniques.

The simplest scanning technique is the checklist, which is merely a listing of potential impact elements. The checklist is employed as a guide for the assesor to ensure a more or less exhaustive impact search. A checklist may frequently be nothing more than a very detailed listing of the factors chosen for reductionist strategy.

A checklist suitable for a specific study can be constructed from scrap or borrowed in whole or part from numerous list appearing in existing assesments. Brain storming, Delphi technique, panel discussion and surveys have been used to generate elements for the construction of checklists.

A matrix formulation can also be done, where two or more dimensions are required for representation. These added dimensions provide increased capacity to represent interdependence impacts and their actual relationship to the matter being assessed.

4.2.1.2 Tracing Techniques

The relevance tree is the simplest and most the commonly employed tracing method. Relevance tree graphically represent the interrelationship or linkages between various members of some set of elements. Trees can be considered as graphical outlines, that progress more or less linearly from the general to the specific. Perhaps the most common examples of trees are family trees and the organisation chart. In the former family lineage is displayed, more or less chronologically and in the later, the various levels represent a hierarchy of authorities.

The advantage of tree representation is that, it simultaneously displays both the linkages and impacts and the scope, of the impact field. Further the structural framework of the method tends to make the search for impacts self-propagating. Disadvantages includes the fact that early ommisions may by-pass sections of the field, leaving some impact undetected.

4.2.2 ANALYSIS OF IMPACT

Analysis links the identification of significant impacts with the evaluation and the formulation of policy options to deal with them. Analysis add substance to the consideration of impacts already identified. The basic features of the impact analysis is to obtain a comprehensive picture of impacts and cross-impacts (or chain) usually through iteration. Therefore an interaction between academicians, scientists and experts having long and useful experience in different disciplines is required. There is no common methodology and some of the techniques that are usually applied in impact analysis are ;

a) Relevance Tree
b) Cross-impact Matrix
c) Brain Storming
d) Delphi Analysis
e) Trend Co-relation.

4.2.2.1 Relevance Tree

A suitable technique with several variants is the relevance tree, which helps, to show how one thing leads to another and how the effects may branch out. One of the shortcomming of a relevance tree is that the feedback elements cannot be conveniently displayed in the tree.

4.2.2.2 Cross-impact Matrix

The effects, the chain-effects and the feedback linkages can be more effectively represented in a cross-impact matrix. This can be either purely qualitative, showing how the occurance of one event, might effect that of another, or it can be quantitative, assigning probabilities of occurence to the various events.

4.2.2.3 Brain Storming

A comprehensive list of probable impacts and chain effects is prepared by a group of persons selected from all relevant disciplines. They are encouraged to behave unrestricted during the session. Thus the preliminary list contains all impacts, which may be thought of. At the end of the session, the list is completed with all rational and practical impacts and cross-impacts.

4.2.2.4 Delphi Analysis

The Delphi Analysis is based on the slighly forced formation of a consensus by a group of experts on the likelihood or timing of certain events. A questionnaire is directed to the panel of experts, whose replies are kept annonymous.

The panel of expert is sent information on the weight of opinion given in the first round and are asked whether and how they wish to modify their first round replies. A third and further round might be entered into, although with each round the number of respondents tends to decrease. Usually after a few iteration, the results become quite representative.

4.2.2.5 Trend Co-relation

This method recognises the relationship of the former one with one step further. It seeks to establish how each of the determinants may really be expected to change with time throughout the years and then to calculate from that how the expected capability will change with time.

4.2.3 THEORIES AND METHOD OF RELATIVE SCALING

4.2.3.1 Thurstone Judgement Scaling Model

Thurstone (24) presented a mathematical model for relating scale values of a set of stimuli to observable proportions. This model has been summarised as follow:

" A psychological continuum of the attribute of interest is postulated. Each time a stimulus is presented to a subject, it brings about some sort of a discriminal process, which has a value on this continuum. Owing to sundry factors, upon repeated presentation, the stimulus is not always associated with a particular value but may be associated with one higher or lower on the continuum. It is prostulated that the values associated with any given stimulus project a normal distribution on the continuum. Different stimuli may have different means (scale values) and different discriminal dispersions (standard deviation)."

An observer cannot report directly the value of the discriminal process on the psychological continuum. Hence it is not possible to obtain directly from the observer the frequency distribution associated with a stimulus. Scaling the stimuli must always be done indirectly. However it is possible to deduce equations, relating judgement of relations among stimuli to the scale values and dispersions of the stimuli on the psychological continuum. One of these sets of equations is known as the law of comparative judgement. This law is concerned with paired comparisons judgements, that is with judgement of the form "stimulus A is greater or less than stimulus B." Another similar set of equations, called the law of categorical judgement is concerned with judgements that require the observer to place the stimuli into a number of ordered categories.

The following are some of the relative scaling techniques in popular use :

a) Ranking technique
b) Rating technique
c) Pairwise comparison technique
d) Preference theory technique.

Among these ranking, pairwise comparison, and preference theory techniques are based on the law of comparative judgements and the rating technique is based on the law of categorical judgement.

4.2.3.1.1. Ranking Techniques

In this model the judge is asked to place a numerical rank next to each criterion, indicating by 1, the most important one with respect to the situation, by 2 the next most important and so on to obtain relative weights the raw ranks are first converted, such that if there are n stimuli to be ranked, then the rank of 1 becomes (n-1), 2 becomes (n-2), etc and rank n becomes 0. These ranks are then treated as follows "

$$R_c = \sum_{j=1}^{n} R_{cj} \quad \ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Where,

R_c = Sum of converted ranks, across judges for each criterio

R_{cj} = Converted rank assigned by judge j to criterion c.

then

$$W_c = \frac{R_c}{\sum_{c=1}^{m} R_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where

W_c = composite weight of criteria c across all judges.

m = number of criteria.

4.2.3.1.2 R.ting Techniques

In this method, instead of presenting all criteria to the judge's at once, they are presented one at a time. The judge task is to rate each criterion based on the situation, the rating may be expressed on a numerical scale (e.g. rate on a scale from 1 to 10, 10 being most important, or on a continuous graphical scale permitting values between numbers.

The raw ratings assigned by the judge to each criterion against the scale are read off to two significant digits (if graphical scale is used) and treated as follows.

$$W_{cj} = \frac{P_{cj}}{\sum_{c=1}^{m} P_{cj}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where

W_{cj} = Weight computed for criterion c from the rating given by judge j.

P_{cj} = rating given by judge j to criterion c.

Then the required composite weight is given by

$$W_{c} = \frac{\sum_{j=1}^{n} W_{cj}}{\sum_{j=1}^{n} \sum_{c=1}^{m} W_{cj}} \quad \ldots\ldots\ldots\ldots \text{(4)}$$

4.2.3.1.3 Pairwise comparison Technique

In this method, each criteria is compared with every one of the other criteria and the judge is asked to indicate which of the criteria being compared is more important. After the raw data is tabulated in a matrix form, the number of times each criterion is chosen over the other criteria is determined by addition.

$$f_{cj} = \sum_{c=1}^{m-1} f_{(c/c')j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where,

f_{cj} = frequency of choice by judge j of criterion c over other criteria

$f_{(c/c)j}$ = frequency of choice of criterion c over criterion c'

then the weight computed for criterion c from the comparisons of judge j is given by

$$W_{cj} = f_{cj}/k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where $k = m(m-1)$ = number of comparisons made.

the required composite weights for each criterion across judge (W_c) may be computed using equation (4).

4.2.3.1.4 Preference Theory Technique

In this technique, criteria in a set are compared two at a time and numerical values are assigned.One to each criterion until all possible combinations have been exhausted. The values to be assigned to each criteria is either zero or one, (0 or 1) depending upon the ordinal results of comparison. If the first criterion is prefered over the second one, 1 is assigned for first criterion and zero for the second criterion. If the second criterion is prefered over the first one, then 1 is assigned for second criterion and 0 for the first criterion. However if neither criterion is preferred then 1 is assigned for both. With the assigned preference values, the weights computed from the evaluations of judge j could be obtained from the equation

$$W_{cj} = \frac{\sum_{d=1}^{n} P_{cd}}{\sum_{c=1}^{n} \sum_{d=1}^{1} P_{cd}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where

P_{cd} = preference rating of criterion c, when compared with criterion d.

[P_{cd} = o or 1 and P_{cc} = o]

c, d = 1, 2 ..... n= number of criteria

Aggregation of weights across the judges (W_c) may be computed using equation (4).

The procedure presented for the computation of weights under the above techniques are not the only ones available. Among the four relative scaling techniques presented here, ranking technique is the simplest and requires minimum time to carry out. However all these techniques are reliable and consistent as long as the raw data is consistent. If the number of criteria to be weighted consist of three to a dozen items, all of these techniques could be used. If the nuwber of criteria increase beyond these limits, the pairwise comparison & preference theory techniques becomes positively time consuming, since the number of comparisons to be made increase exponentially with the number of criteria to be weighted. Further it should be noted that the use of any of these techniques produces first order results only, which is to say, no indication of the interaction among criteria is available through these methods.

4.2.3.2. Likert scoring method

Likert (25) has suggested a technique for arriving at a score on an attitude questionnaire which is a simple extension of mental testing technique. In mental testing, the items are dichotomous (pass/fail) and the patterns of response are mapped into the integers by counting all the favourable (passing) element in a response pattern. Likert's system is necessarily confined to monotone items. The techniques is to take a statement of opinion sufficiently extreme, so that it cannot act nonmonotonically that is, so that there are not likely to be any people so extreme, that they would reject the item for not being sufficiently extreme. To such an item, a degree of endorsement is obtained, typically from strongly agree to strongly disagree. The simplified scoring method is to map these alternatives into the integers e.g 1 to 10, so that 1 represent the extreme pro answer and 10 the extreme anti. The individual's scrore, then may be simply the sum of those integers into which his responses have been mapped. Obviously this corresponds identically to scoring a mental test except that in the latter the response categories fail or pass are mapped into 0 and 1 respectively.

Likert also discussed a more 'refined' scoring procedure called the sigma method of scoring. The assumption is that the distribution on the underlying attribute is normal. The percentage of individuals in a given category is converted into a sigma value and the value is used instead of integers into simplified scoring system.

In Likert scale ordinal values are associated with qualitative attributes. As an example, let the attribute be, " measure of acceptability" for which the associated Likert scale would appear as follows :

	very poor				acceptable			outstanding		
Impression	1	2	3	4	5	6	7	8	9	10

The respondent is asked to mark his or her response on the scale. The mark then define an assumed measure of acceptability for the determinant in question.

4.2.4. EIGEN-VALUE APPROACH TO SETTING PRIORITIES

Let there be n activities and their actual relative priorities are w_1 $w_2, \ldots, w_n$. Further let A be an (n,n) matrix of pair-wise comparison, whose elements are assigned from table - (1) given below. These elements a_i, may be regarded as an estimateof the ratio w_i/w_j.

Now if it is assumed that the estimates are precise and consistent then

$$a_{ij} = \frac{w_i}{w_j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots, \quad (8)$$

and $a_{ij} \cdot a_{jk} = a_{ik} \quad \ldots\ldots\ldots\ldots\ldots (9)$

Where,

w_i, w_j are respective weightages.

Table - (1)

Scale of Relative Importance

1. Equal importance
3. Weak dominance
5. Strong dominance
7. Demonstrated dominance
9. Absolute dominance

2, 4, 6, 8 : Intermediate values

i.e. $a_{ii} = 1 \quad \ldots\ldots\ldots\ldots \quad (10)$

$$a_{ji} = \frac{1}{a_{ij}} \quad \ldots\ldots\ldots\ldots (11)$$

Further as the rank of A is unity, the sum of its eigen-values is equal to its trace.

$a_{ii} = n$. Its largest eigen value is equal to n and all other eigen values are zero.

In general, consistency is not expected to hold everywhere in the judgement matrix A. However by maintaining the reciprocal relatiion

$$a_{ji} = \frac{1}{a_{ij}} \quad \ldots\ldots\ldots\ldots\ldots (12)$$

The consistency could be improved.If inconsistency is allowed in A, then the relation.

$$a_{ij} \cdot \frac{W_j}{W_i} = 1 \ (i,j \quad = 1 \ \ldots\ldots n) \ldots\ldots\ldots\ldots (13)$$

is not true.

To arrive at the eigen-value formulation of the general problem, we have to note that in the consistent case.

$a_{i1} \cdot w_1 = w_i$
$a_{i2} \cdot w_2 = w_i$
$a_{i3} \cdot w_3 = w_i$
....
....

$a_{in} \cdot w_n = w_i$

ie AW=nW ....(14)

In the general case the AW doesnot yield exact λW, but deviations about then, which amount to perturbations of exact values. It is known in matrix theory that the eigen values of a matrix are continuous functions of the co-efficients. Hence for small perturbations in a_{ij}, the largest eigen value λmax remain close to n and other eigen values near zero. Thus the problem of finding W becomes solving

$$AW = \lambda \max W \quad \ldots\ldots\ldots\ldots (15)$$

The results would be more valid, the closer λ max is to n as indicated in the index of consistency.

$$[\quad (\lambda \max - n) / n-1 \quad]$$

The required weights are given by the normalised eigen vector.

4.2.5 THEORIES AND METHODS OF INDEXING

Index numbers have a long history dating back to 1887, when Edgeworth , Secretary of a committee of the British Association set up to study methods of measuring variations in the value of money, defined and used as index number to measure the fluctuations of the purchasing power of money. Index numbers are used to measure the change in some quality which is not observable but known to have a definite influence on many other observable quantities. It is limited to the measure of changes or relative difference in the magnitude from one situation to another. The two situations compared are in no way restricted, they may be two time periods, two regions, or any two entities. Aggregation techniques, taxonomic analysis, factor analysis and eigen value analysis are some of the techniques used to formulate index numbers. Aggregate or composite index numbers are constructed by combining a number of indices, involving some system of weighting. Methods of aggregation could be

a) Additive forms, such as linear sum or weighted sum.

b) Multiplicative form such as weighted product.

c) Root sum power form.

d) Maximum operator.

e) Minimum operator.

4.2.5.1 Additive form

The simplest aggregation functions are the additive forms or the addition of unweighted sub-indices, in which no sub-index is raised to a power other than 1.

$$I = \sum_{i=1}^{n} I_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

Where,

I_i = subindex for variable i

n = number of variables.

From equation (16) it could be observed that if the sub-indices are defined such that $0 \leqslant I_i \leqslant I_{max}$, then the possible range of I, becomes 0 to Imax. Thus there is according to Olt (26), a region of ambiguity with values of I between I_{max} and nI_{max}. Further depending on the number of subindices being aggregated, larger aggregate indices may result from very moderate or small sub-indices. Thus there is also a problem of exaggeration in this method.

By multiplying each sub-index by an appropriate weight, this could be modified to remove the ambigions region.. Usually the weights are selected so that, their sum is unity. The weighted linear sum has the following general form

$$I = \sum_{i=1}^{n} W_i I_i \quad \ldots\ldots\ldots\ldots\ldots \quad (17)$$

Where $\sum_{i=1}^{n} W_i = 1$ .... (18)

Although the weighted linear sum doesnot have an ambigious region, another problem is introduced this is called "eclipsing" and it reflects an underestimation rather than exaggeration, of the index. Even if some of the sub-indices exceed a critical value, the overall aggregate index usually does not reflex this fact, thus eclipsing certain extreme values.

4.2.5.2 Multiplicative Form

The most common multiplicative aggregate function is the weighted product, which has the following form.

$$I = \prod_{i=1}^{n} I_i^{w_i} \quad \ldots\ldots\ldots\ldots \quad (19)$$

Where $\sum_{i=1}^{n} w_i = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$

In this case, if the maximum values of each sub-indices is I_{max}, then the maximum value of aggregate index will also be I_{max}. The weights in equation (19) sum to unity as show in equation (20) inclusion of a large number of sub-indices has the effect of making each weight relatively small. If W is very close to zero, the subindex is transformed such that it can take on essentially just two states and the aggregation function, in effect becomes a step function. Multiplicative forms have found acceptance in aggregating decreasing rather than increasing indices.

4.2.5.3 Root sum power Form

To deal with the problem of exaggeration and underestimation a more complex additive form is available. The root sum power form, is a nonlinear aggregation of the following form

$$I = \left[\sum_{i=1}^{n} I_i^{p} \right]^{i/p} \quad \ldots\ldots (21)$$

Where

p is a positive real number greater than 1.

As p increases from 1 to (infinity), the root sum power exhibits a progression of shapes. When P=1, a straight line results, which is the weighted linear sum aggregation function.For larger values of p, the ambigious regions become small and is completely eliminated when p approches infinity.

For the limiting case in which p approaches infinity, the root-sum-power has desirable properties for aggregating sub-indices. It possesses neither an eclipsing region nor an ambigious region. However because it is a limiting function, it is somwhat unweildy to use. A simpler function with the same properties is the maximum operator.

4.2.5.4 Maximum Operator

The general form of the maximum operator is as follows:

$$I = \max [I_1, I_2 \ldots\ldots I_n] \quad \ldots\ldots\ldots (22)$$

With this method there is no-region eclipsing or ambigious. However the limitations of themethod, becomes apparent when fine gradation of certain characteristics, rather than extremes are to be reported.

The maximum operator is ideally suited to applications in which an index must report if at least one recommended limit is violated.

4.2.5.5 Minimum Operator

This method, when applied to decreasing scale sub-indices, performs in a fashion similar to the increasing scale maximum operator. The general form of the minimum operator is as follows :

$$I = \mathrm{Min} [I_1, I_2 \ldots\ldots\ldots I_n] \quad \ldots. (23)$$

In aggregation by weighted sum, problem of underestimation arises, but it is irrelevant when dealing with relative indices, as the underestimation is common to all the indices computed and doesnot affect the relative position of the index number in rank order. Other forms provide better aggregation but increase the computational complexity.

4.3 ANALYTICAL FRAMEWORK OF THE MODEL

An aggregate index is proposed here, to measure the knowledge and skills of a craftman of a particular trade or vocation by quantifying the qualitative variables and using suitable methods of aggregation. The knowledge elements have been classified under three objective factors, namely :

a) Knowledge of Science.
b) Knowledge of Technology.
c) Productive Skills.

If Q be denoted to represent the index, then Q can be given by

$$Q = \phi_1 X + \phi_2 Y + \phi_3 Z$$

where

Q = knowledge index

ϕ_1, ϕ_2, ϕ_3 = respective weightages between factors, and $[\phi_1 + \phi_2 + \phi_3 = 1]$

X = weighted sum of the factor: knowledge of science.

Y = weighted sum of the factor: knowledge of techgnology

Z = weighted sum of the factor: productive skills. and they are given by

$$X = \sum_{i=1}^{n} \alpha_i X_i$$ $i = 1,2 \ldots\ldots n$ are

the sub-factors of the factor: knowledge of science.

$$Y = \sum_{j=1}^{m} \beta_j Y_j$$ $j = 1,2 \ldots\ldots m$ are

the sub-factors of the factor: knowledge of technology.

$$Z = \sum_{k=1}^{l} \gamma_k Z_n$$ ..... $k=1,2 \ldots\ldots l$ are

the sub-factors of productive skills.

$\alpha_i, \beta_j, \gamma_k$, are the respective weightages and

$\sum \alpha_i = 1$, $\sum \beta_j = 1$ and $\sum \gamma_k = 1$

The integrated model can be developed, in the following successive steps.

1) Identification of elements that are relevant to the learning process of a craftman especially for a particular trade. The scanning technique or the tracing technique or the combination morphological analysis can be used to identify the impact elements.

2) The identified elements are to be analysed and classified into Knowledge of science factor, Knowledge of technology factor and productive skill factor. Each factor should be further classified into sub-factors having common attribute. The tools that can be employed for analysis are relevance tree, cross-impact matrix, brain storming and trend co-relation.

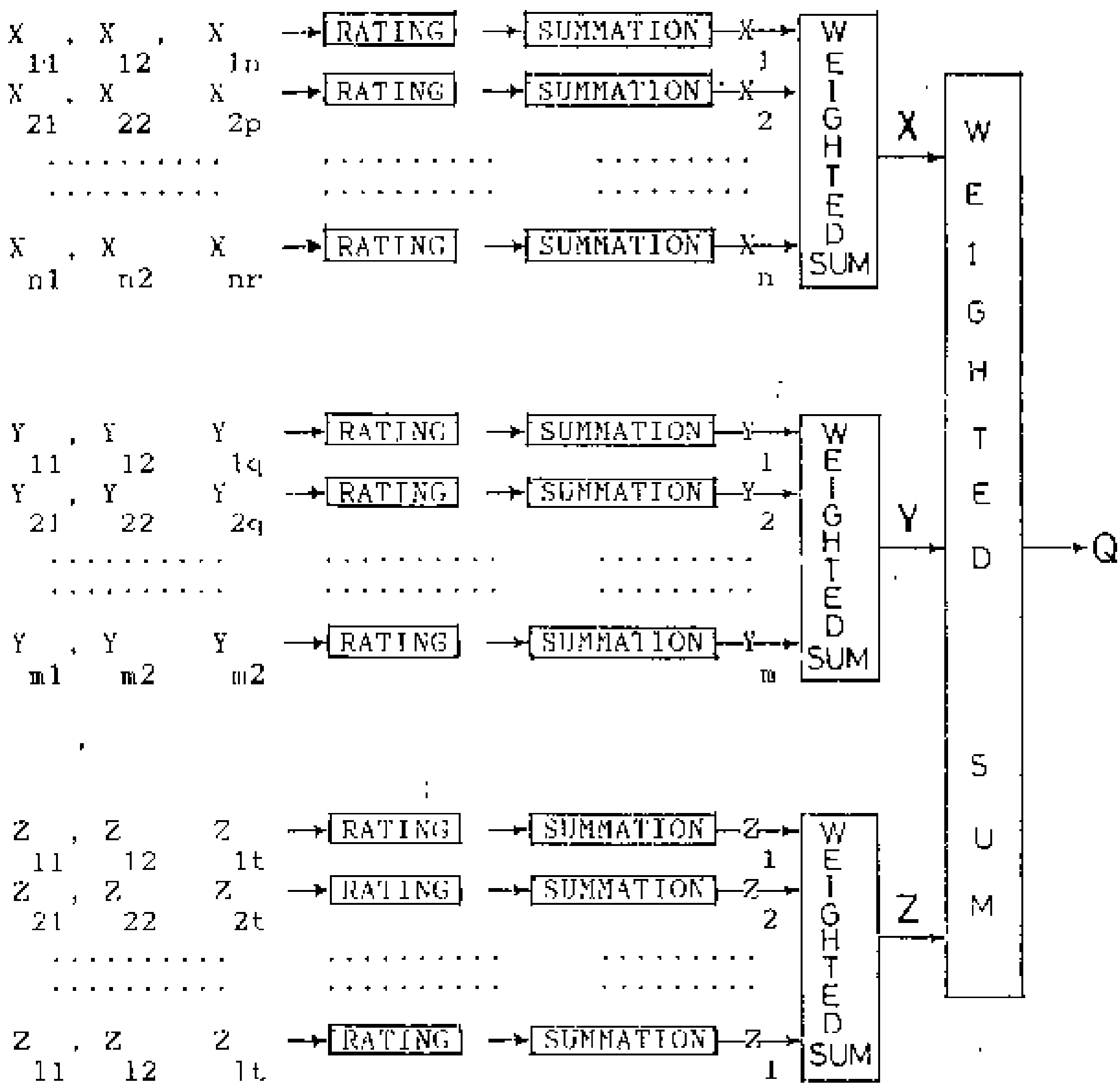
3) The next step is to make pairwise comparison among the three factors and also among the various sub factor under each factor, to form the respective priority matrices using some relative importance scale.

The "normalised eigen vectors" obtained from the matrices, form the consistent set of weightages between the different factors and between different sub-factors of each factor.

4) The various elements of each sub-factor are given a raw rank in order of their importance to the particular trade, by a number a judges. The raw ranks are then converted into " standardised scores" using the ranking technique of relative scaling. The derived scores are the relative weightages of each element in respect of the particular sub-factor.

(5) The last step is the aggregation of the various sub-factors to form the factor score and the aggregation of the different factor score to form the "aggregate index." The weighted linear sum method of aggregation has been used to formulate the aggregate index.

FIG:2 DEVELOPMENT OF THE AGGREGATE INDEX



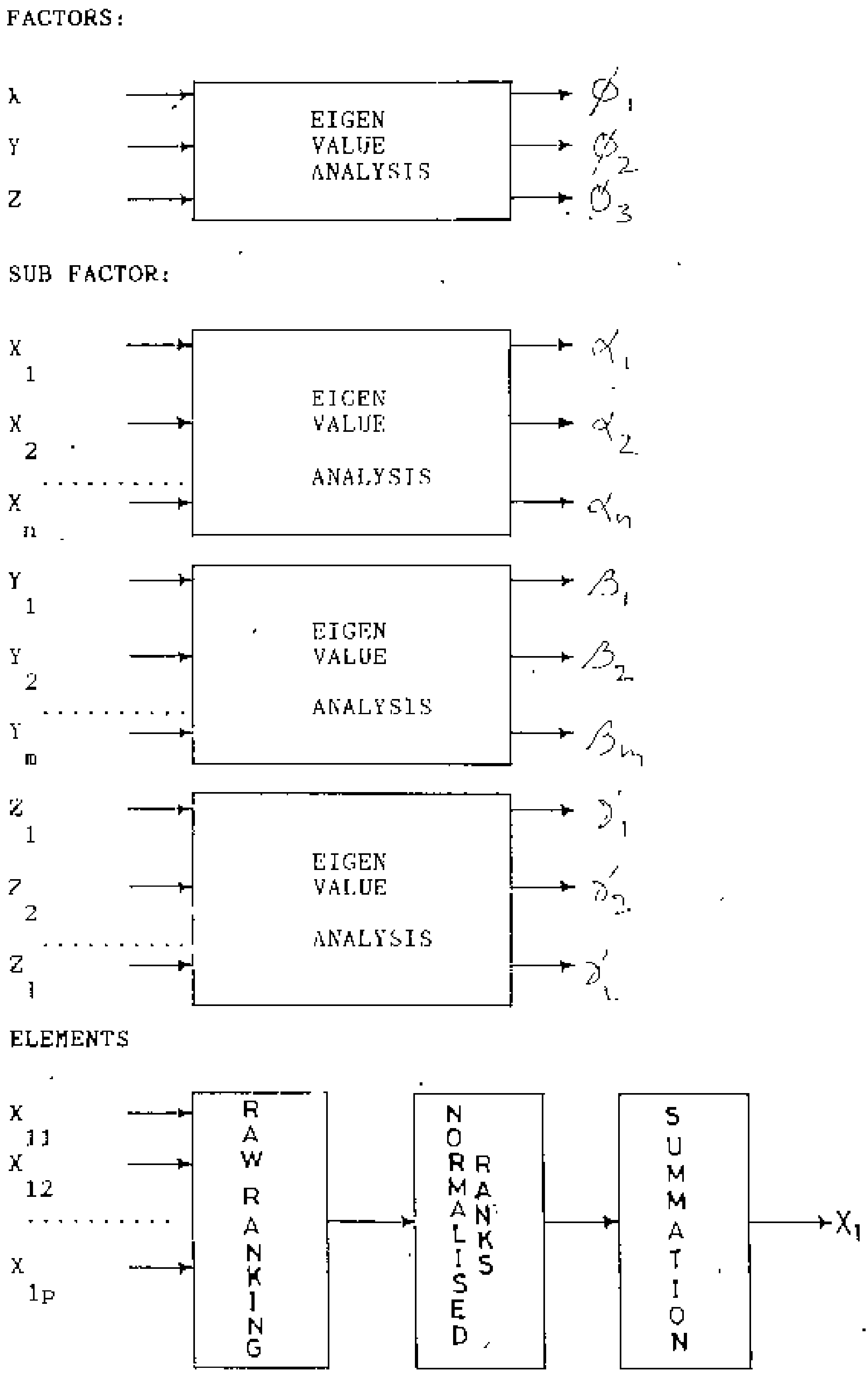
Q = Aggregate Index of knowledge

X = Knowledge of science

Y = Knowledge of technology

Z = Productive skills

FIG : 3 INFORMATION FLOW DIAGRAM.



4.4 EVALUATION TECHNIQUES

Evaluation is a decision making process. " It is a judgement of merit, sometimes based solely on measurements such as those provided by test scores but more frequently involving the synthesis of various measurements, critical incidents, subjective impressions and other kinds of evidence." (27) In a deliberately designed training process, teacher made tests, objective tests, oral examination can be easily used, as the learning is directed and its content is defined. But to evaluate a person coming out of a non-training program like doing-based learning, the need is to find out, what are his abilities. The question that first crops up is how to find them out ? Here the model developed in this thesis is proposed to be used.

But the problem remains, with whom can his performance be compared.A set of performance standards have to be predetermined and also methods to score and rate them. The first place to look at isjob descriptions followed by job requirements. But most job descriptions available usually list job activities rather than accomplishments. Further more they usually fail to overlap very much with what a craftsman usually does. Recognising all these the characteristics and difficulties of every 'job-element' have to be analysed and:

a) accomplishments that an average will generate, should be found.

b) the upper and lower limit of job performance that can be accepted should be determined.

Such performance standards to be valid must also be completely measureable by quantifiable yardstick. For some characteristics a zero-one method of quantification and for some others fractional grading might be required. For some others, physical demonstration or "try-outs' will be needed. For measuring productive skills, job observation and grading on the Likert scale can be recommended.

Given below is a numerical method of evaluation adapted from Havelink Jack and Hamelink Jerry (28) where subjectivity of performance appraisal has been reduced.

4.4.1 NUMERICAL PLAN FOR PERFORMANCE EVALUATION

In this method, the yardstick (performance standards) for every key element is tailored to the job. The appraiser or evaluator has to rate the actual performance in view of the set performance standards. Each key elements have a weighing factor, based on standardised rating as descriped in the generalised model.

A worker who has an overall " standard" rating is a satisfactory or "skilled" worker. An upper limit of "Above standard" and a lower limit of "Below standard" can also be set. But usually all workers will not show "above standard" or "below standard" in all key elements. Some key elements will be performed above standard, some at standard and some at below standard by most worker.

In equation form

a) If $AP - PS > 0$ then

$$AP - PS = AS$$

b) If $AP - PS < 0$ then

$$AP - PS = BD \text{ or } D$$

where

- AP = actual performance
- PS = performance standards
- AS = above standard
- BD = below standard
- D = deficiency

Since, in theory one's performance is what gets him/her somewhere, performance should be expressed as a vector quantity, i.e. which has both magnitude and direction.

Rewritting the above two equations yield

c) $$\vec{AP} - \vec{PS} = \vec{AS},$$
when $AP - PS > 0$

d) $$\vec{AP} - \vec{PS} = \vec{D}$$
when $AP - PS < 0$

the resolution, of the overall performance can then be obtained by calculating the (RMS) Root mean square of the mobility vectors AS and D . Therefore, for "k" key elements, where I+J <= k;

e) $RMS = \sqrt{(\overline{D} \cdot \overline{D})} - \sqrt{(\overline{AS} \cdot \overline{AS})}$
where i= 0 -> n key elements where a deficiency exists and j= 0 -> m key elements where the performance is above standard.

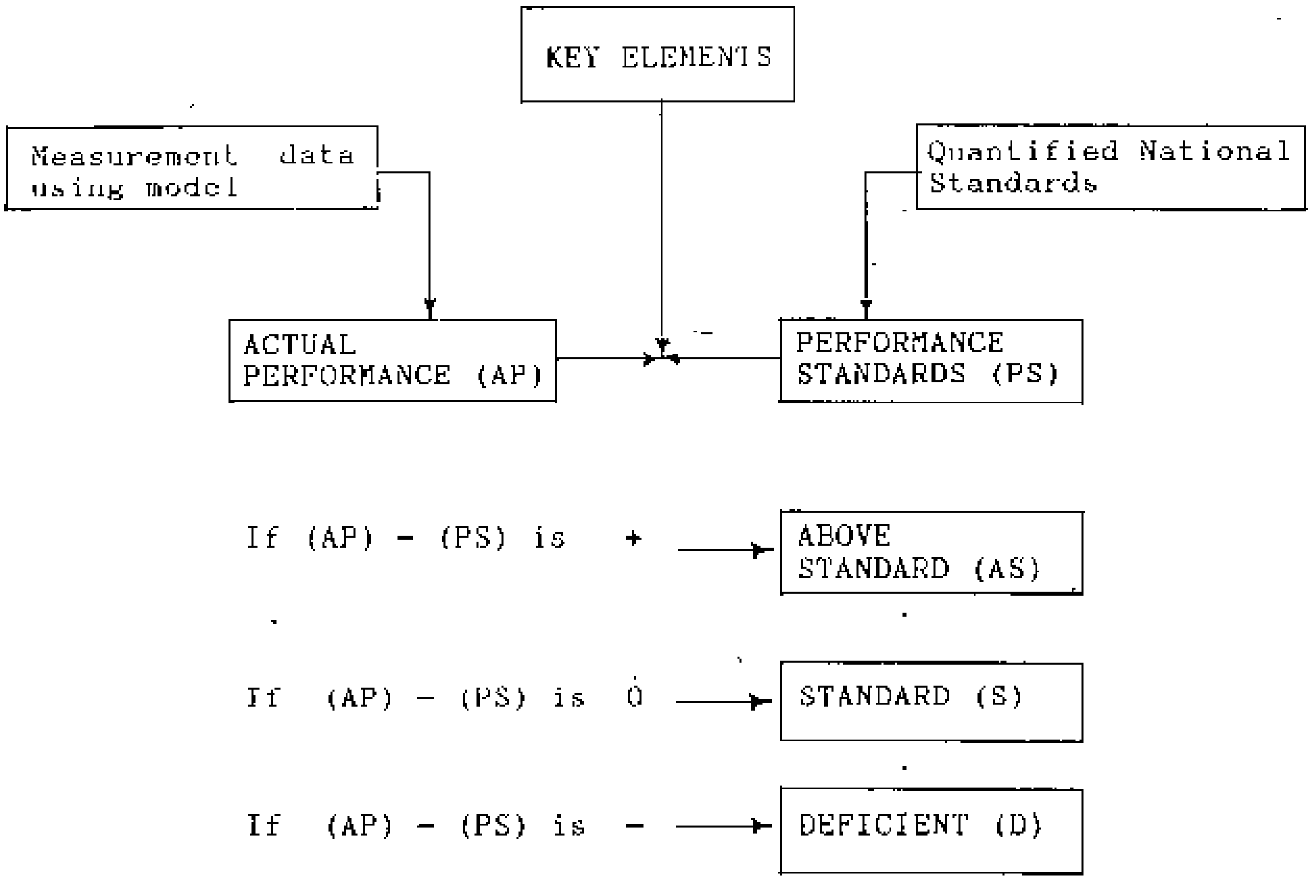


Fig: 4. A PERFORMANCE EVALUATION MODEL BASED ON GENERALISED MODEL DEVELOPED IN THIS STUDY.

5.0 APPLICATION OF THE MODEL

5.1 MORPHOLOGICAL ANALYSIS OF "TURNER" TRADE

Lathe had been among the first machines used by man. The drawing of the most primitive form of lathe can be found, on an ancient Egyptian tomb relief. It was used for shaping wooden artefacts. Over the years the development of lathe have reached a matured stage and lathe now constitutes a considerable part of the machines and equipments used in engineering industry. Almost all workshops start with a lathe, and perhaps the trade of 'turner' was among the first technical vocation learnt by man. It is still the most widely used vocation in engineering industries.

Considering these facts, the trade of 'turner' has been selected as the 'specific example' to show the application of the generalised model. To prepare the 'specific scale' the basic features of a centre lathe and its operational aspects have been morphologically analysed and a 'checklist' prepared. In the checklist the various elements of the lathe and its operations have been grouped under the following heads.

a) Machine
b) Job
c) Tool
d) Job/Tool
e) Measurement
f) Drawings

Details of the checklist is presented in Appendix - A.

4.0 DEVELOPMENT OF THE GENERALISED MODEL

In an attempt to formulate a model to measure the quality of educational achievement a number of characteristics are relevant. To start with, it is desirable to define the problem area and then proceed to find the different tools and techniques of measurement, currently available. Later on it might be possible to sort out the various ideas and integrate them.

4.1 DEFINING THE PROBLEM AREA

4.1.1 Knowledge

As defined in Webster New Collegiate Dictionary (17) "Knowledge" is :

a) Familiarity gained by actual experience.

b) Acquiantance with facts, hence, scope of information.

c) The act or state of understanding, or cognition.

d) That, which is gained and preserved by knowing, enlightment, learning.

This definition suggests the scope of the concept of knowledge, and its relationship to or identity with experience, fact, information, understanding, enlightment, and learning. Phychologists suggest that what a person has experienced or learned is never completely forgotten. It all remains somewhere, however deeply burried and overlaid with other learning and experiences. Not all of the items in this store of knowledge are of equal value. Some are of limited, temporary interest, some are indefinite and inaccurate. One of the most important and most difficult tasks of analysis is to sort out the more valuable ones from the less valuable. It is easy to say, that those items of knowledge which are most widely useful or most central

The next step is to establish priorities. All elements listed in the "Check-list" have been modified, related, classified and sharpened to prepare the priority matrices. The tools that have been used are scaning, tracing and pair-wise comparison. A questionnaire was prepared which is given in appendix -B and was directed to a group of experts drawn from persons who train turners, to determine the relative importance of each factor, each sub factor and each element in each particular class. The experts numbering [illegible] fifteen(15) were selected from among the instructors at the Bangladesh - German Technical Training Centre, Mirpur Technical Training Centre, the training workshop of BUET and supervisors at the machine shops of Khulna Newsprint Mills, a unit of Bangladesh Chemical Industries Corporation.

The specific model for the trade of turner has been developed in the following way. The various sub-factors of the factor : knowledge of science, the factor : knowledge of technology and the factor : productive skills which have been identified are presented below :

Factor: Knowledge of Science

X_1 = Numeracy $\longrightarrow X_{11}, X_{12} \ldots\ldots X_{1s}$

X_2 = Geometry $\longrightarrow X_{21}, X_{22} \ldots\ldots X_{2t}$

X_3 = Drawing $\longrightarrow X_{31}, X_{32} \ldots\ldots X_{3u}$

X_4 = Basic Science $\longrightarrow X_{41}, X_{42} \ldots\ldots X_{4v}$

X_5 = Material

Science $\longrightarrow X_{51}, X_{52} \ldots\ldots X_{5w}$

X_i = Sub-factor

X_{ii} = Elements

Factor: Knowledge of Technology

Y_1 = Job setting $\rightarrow Y_{11}, Y_{12}, \ldots\ldots Y_{1q}$

Y_2 = Tool selection $\rightarrow Y_{21}, Y_{22}, \ldots\ldots Y_{2r}$

Y_3 = Tool setting $\rightarrow Y_{31}, Y_{32}, \ldots\ldots Y_{3s}$

Y_4 = Speed selection $\rightarrow Y_{41}, Y_{42}, \ldots\ldots Y_{4t}$

Y_5 = Coolant selection $\rightarrow Y_{51}, Y_{52}, \ldots\ldots Y_{5u}$

Y_6 = Lathe operations $\rightarrow Y_{61}, Y_{62}, \ldots\ldots Y_{6v}$

Y_7 = Operation sequence $\rightarrow Y_{71}, Y_{72}, \ldots\ldots Y_{7w}$

Y_8 = Use of gages/ measuring tools $\rightarrow Y_{81}, Y_{82}, \ldots\ldots Y_{8x}$

Y_9 = Tool regrinding $\rightarrow Y_{91}, Y_{92}, \ldots\ldots Y_{9z}$

Y_j = Sub-factor

Y_{jj} = Element.

Factor: Productive Skill

Z_1 = Reasoning

Z_2 = Confidence

Z_3 = Creativity

Z_4 = Experimentation

Z_5 = Dissemination

Z_k = Sub-factor.

The responses, varied widely and a set-of reformed tables have been formed from the ' mode' of the responses of every criteria, which is presented below: Eigen values and vector approximation has been done by using "ACRITS" software package at the BLET Computer Centre.

RESULTS OF EIGEN VALUE ANALYSIS

a) Pairwise comparison among different factors.

The reformed matrix 'A'

	Knowledge of Science	Knowledge of Technology	Productive skills
Knowledge of Science	1	5	1/3
Knowledge of Technology	1/5	1	5
Productive Skills	3	1/5	1

EIGEN VALUES :

	5.45350	0.00000	0.00000

EIGEN VECTORS :

	0.67144	0.00000	0.00000
	0.56652	0.00000	0.00000
	0.47774	0.00000	0.00000

b) Pairwise comparison among different sub-factors of the factor "Knowledge of Science.

The reformed matrix 'B'

	Knowledge of Numeracy	Knowledge of geometry	Knowledge of Drawing	Knowledge of Basic Science	Knowledge of Material Science
Knowledge of Numeracy	1	6	1/4	1/5	4
Knowledge of geometry	1/6	1	7	3	2
Knowledge of Drawing	4	1/7	1	2	1/3
Knowledge of Basic Science	5	1/3	1/2	1	2
Knowledge of Material Science	1/4	1/2	3	1/2	1

EIGEN VALUES:

9.15937	0.00000	5.14965	0.00000	0.00000

EIGEN VECTORS

0.54340	0.02009	0.10672	0.00000	0.00000
0.56055	0.00000	0.44184	0.00000	0.00000
0.39134	0.97633	0.53359	0.00000	0.00000
0.43393	0.00000	0.70519	0.00000	0.00000
0.22148	0.21536	0.10672	0.00000	0.00000

c) Pairwise comparison among different sub-factors of the factor "Knowledge of Technology".

The reformed matrix 'C'

	Job Setting	Tool Selection	Tool Setting	Speed Setting	Lathe Operation	Operation sequence	Use of Gages	Tool Regrinding	Coolant Selection
Job Setting	1	3	5	4	6	5	4	1/2	5
Tool Selection	1/3	1	5	1/6	5	6	1/3	1/5	1/6
Tool Setting	1/5	1/5	1	4	6	4	1/3	3	1/3
Speed Setting	1/4	6	1/4	1	1/5	7	3	1/4	1/3
Lathe Operation	1/6	1/5	1/6	5	1	4	1/2	1/6	1/5
Operation sequence	1/5	1/6	1/4	1/7	1/4	1	3	1/4	1/4
Use of Gages	1/4	3	3	1/3	2	1/3	1	1/7	1/2
Tool Regrinding	2	5	1/3	4	6	4	7	1	1/5
Coolant Selection	1/5	6	3	3	5	4	2	1/5	1

The reformed matrix 'C'

-EIGEN VALUES

13.99935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

EIGEN VECTORS

0.58145	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.25361	0.00000	0.00000	0.00000	0.00000	0.00000	0.00030	0.00000	0.00000
0.31123	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.24584	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.15527	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.08499	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.19361	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.47844	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.37759	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pairwise comparison among the sub-factors of the factor " Productive Skills"

The reformed matrix 'D'

	Reasoning	Confidence	Experimentation	Dissemination	Creativity
Reasoning	1	1/5	1/5	1/5	4
Confidence	5	1	1	1/3	5
Experi-mentation	5	1	1	1	5
Dissemination	5	3	1	1	5
Creativity	1	1/5	1/5	1/5	1

EIGEN VALVES:

0.00000	0.00000	5.14965	0.00000	0.00000

EIGEN VECTORS

0.18690	0.02009	0.10672	0.00000	0.00000
0.00000	0.00000	0.44184	0.00000	0.00000
0.98233	0.07633	0.53359	0.00000	0.00000
0.00000	0.00000	0.70519	0.00000	0.00000
0.00957	0.21536	0.10672	0.00000	0.00000

As discussed in section 4.2.2, according to the theory of eigen-value analysis, the eigen vectors for the largest eigen value gives the consistent set of relative priorities. The required weightages are obtained by converting the eigen vector into their normalised scores. The tables 2,3,4,5 given below presents the set of relative weightages between factors, sub-factors of each factors respectively. The weights for the elements of each sub-factors are obtained by converting the raw ranks given by the judges into their standardised scores by using the ranking technique, discussed in section 4.2.3.1.1, and is presented in table 6,7,8,9,10 and 11.

Table - 2.

Comparison between factors.

Sl.No.	Factor	Weightages.
1.	Knowledge of Science	0.392
2.	Knowledge of Technology	0.330
3.	Productive Skills	0.278
		1.000

Table - 3

Comparison between sub-factors of the factor Knowledge of Science.

Sl.No.	Sub-factor	Weightages
1.	Numeracy	0.253
2.	Geometry	0.261

3.	Drawing	0.181
4.	Basic Science	0.202
5.	Material Science	0.103
		1.000

Table - 4

Comparison between sub-factors of the factor Knowledge of Technology.

Sl.No.	Sub-factor	Weightages
1.	Job setting	0.218
2.	Tool selection	0.096
3.	Tool setting	0.116
4.	Speed setting	0.092
5.	Lathe operation	0.058
6.	Operation sequence	0.032
7.	Use of gages	0.072
8.	Tool regrinding	0.175
9.	Coolant selection	0.141
		1.000

Table - 5

Comparison between sub-factors of the factor Productive Skills.

Sl.No.	Sub-factor	Weightages
1.	Reasoning	0.056
2.	Confidence	0.231
3.	Experimentation	0.282
4.	Dissemination	0.375
5.	Creativity	0.056
		1.000

Table - 6

Comparison between elements of the sub-factor Knowledge of Numeracy.

Sl.No.	Elements	Weightages
1.	Units of linear measurement	0.233
2.	Units of angular measurement	0.160
3.	Area	0.126
4.	Volume	0.080
5.	Decimals	0.171

6.	Fractions	0.137
7.	Ratio	0.051
8.	Average	0.040
9.	Percentages	0.002
		1.000

Table - 7

Comparison between the elements of the sub-factor Knowledge of Geometry

Sl.No.	Elements	Weightages
1.	Straight line	0.139
2.	Curve	0.071
3.	Traingle	0.086
4.	Square	0.118
5.	Rectangle	0.093
6.	Circle	0.099
7.	Angle	0.088
8.	Radius	0.053
9.	Polygon	0.053
10.	Centre	0.088
11.	Parallelism	0.043
12.	Taper	0.043
13.	Height	0.059

14.	Cylinder	0.043
15.	Conical	0.018
16.	Threaded	0.016
		1.000

Table - 8

Comparison between the elements of sub-factor
Knowledge of drawing

Sl.No.	Elements	Weightages
1.	Plan	0.201
2.	Elevation	0.163
3.	Cross-section	0.114
4.	Projection	0.118
5.	Dimension	0.141
6.	Tolerence	0.146
7.	Representation of Surface finish	0.092
8.	Graphs	0.025
		1.000

Table - 9

Comparison between the elements of sub-factor Knowledge of basic science

Sl.No.	Elements	Weightages
1.	Mass	0.183
2.	Time	0.172
3.	Temperature	0.094
4.	Force	0.156
5.	Pressure	0.144
6.	Voltage	0.067
7.	Current	0.062
8.	Resistance	0.033
9.	Power	0.067
10.	Specific gravity	0.022
		1.000

Table - 10

Comparison between the elements of the sub-factor Knowledge of material science

Sl.No.	Elements	Weightages
1.	States of matter	0.127
2.	Expansion of matter	0.091

3.	Physical properties of matter	0.173
4.	Common working materials	0.191
5.	Common Tool materials	0.182
6.	Common heat treatment	0.127
7.	Types of cutting fluid	0.073
8.	Properties of cutting fluids	0.036
		1.000

Table - 11

Comparison among the elements of the sub-factors of the factor : Knowledge of Technolgy

Sub-factors / Operations	Job setting	Tool selection	Tool setting	Speed setting	Lathe Operation	Operations sequence	Use of gages	Tool Regrinding	Coolant selection
1. Outside Rough Turning	0.082	0.061	0.070	0.076	0.083	0.075	0.053	0.061	0.066
2. Outside Finish Turning	0.063	0.070	0.060	0.080	0.072	0.070	0.093	0.045	0.104
3. Chamfering	0.051	0.075	0.083	0.076	0.076	0.075	0.053	0.121	0.039
4. End facing	0.059	0.077	0.080	0.073	0.072	0.033	0.053	0.121	0.039
5. Knurling	0.089	0.072	0.083	0.068	0.072	0.075	0.040	0.045	0.104
6. Necking	0.066	0.074	0.086	0.060	0.062	0.061	0.134	0.061	0.039

7. Drilling	0.066	0.077	0.064	0.080	0.062	0.023	0.105	0.182	0.091
8. Boring	0.077	0.072	0.057	0.060	0.076	0.089	0.067	0.061	0.051
9. External Taper turning	0.077	0.070	0.060	0.063	0.083	0.093	0.053	0.061	0.051
10. Internal Taper turning	0.083	0.057	0.068	0.076	0.076	0.089	0.060	0.030	0.078
11. External Threading	0.068	0.072	0.068	0.068	0.079	0.093	0.053	0.045	0.066
12. Internal threading	0.083	0.072	0.068	0.068	0.072	0.079	0.053	0.045	0.104
13. Parting	0.054	0.077	0.083	0.089	0.062	0.061	0.067	0.061	0.051
14. Key/ slot cutting	0.086	0.074	0.070	0.063	0.053	0.084	0.099	0.061	0.051

6.0 CONCLUSION & RECOMMENDATIONS

6.1 CONCLUSION

Developing countries today are confronted with the problem of non-availability of indigenous human resources to handle the machines and equipments imported from developed countries on one hand and problem in utilizing surplus educated manpower on the other.Following the concern for non availability of skilled hands informal learning routines began to be explored. This could on one hand reduce the time span required to train persons, who have to learn from basics. On the other, the process, being inexpensive and self-supporting, would require marginal investments. There had been a lot of discussion about, how to develop and enhance these skills. But certainly there had not been an equal amount of attention, given to the identification of methods of measuring and evaluating these skills. It had often been felt that the craftstman and workers for doing certain jobs must meet certain professional standards. Some steps have recently been taken in this direction and National Skill Standards and Certification System has been developed, but the need for a standardised testing method still remains.

The total endeavour of this study has been to analyse the different modes and methods of learning, with special reference to craft learning, and to device a suitable and effective process of measurement and evaluation of the achievement. For a craftsman, the learning process consists of two stages, the first stage is the `acquisition' phase and the second the `application' phase. Both the stages have been taken into consideration in the `aggregate index'. The discriminating contribution of different knowledge elements have been accounted for, by the use of relative weightages. The influence of personal judgement of the evaluator has been considerably reduced by the use of quantified scale for the qualitative attributes. Various methods of measuring the outcome of learning have been discussed and suitable ones identified.

The emphirical evidence that has been found reinforces the grounds for believing that all items of what is learnt or taught do not contribute equally to the process of skill acquisition.The results of this research demonstrate a possibility of simultaneously increasing the importance of some elements of knowledge that has to be imparted to a craftsman while decreasing the importance of others whose contribution to the skilled development process is not very significant .The use of Eigen Value analysis to find the relative weights is indisputable, as the normalised eigen vectors will be consistent as long as the input data are consistent.

Seriously, the new appraisal process is a large step forward in the direction of reducing subjectivity of performance appraisal. While the evaluation of human beings will always retain certent extent of subjectivity because of the uniqueness of the creature, much care have been taken to ensure that the appraisal represent the individual`s singular output.However, it should be noted that the data provided by this model is valid only at the time of analysis.Since the requirements of a specific trade will vary with the overall improvement in technology, the model should be updated, time to time, to find the correct decision weights .

All typologies, classification or models involve arbitrary judgements. This one is no exception. But as Hoffer (31) said of his book, `The True Believer', this volume also in most instances does not " shy away from half truths, .so long as they seem to hint at a new approach and to help to formulate new questions."

Various policy options can be drawn from the study and further work can be undertaken. Some recommendations are presented in the sections 6.2 & 6.3.

6.2 RECOMMENDATIONS

1. The proposed model should be applied for the pupose of skill testing and certification of wokers. Appropriate application models for specific trades can be constructed from the generalised model.

2. Artisan/craftman up-grading training should be periodically arranged at different skill generating centres of the country, e.g. Dholai Khal. These courses should be designed to teach one functional subject module at a time, for a period of seven to twenty evenings.

3. Evening trade courses should be further strengthened and apprentice training scheme implemented at large and medium scale industries. Assistance should be extended to develop the informal skill generating process in the small workshops and industries.

4. Algorithmic and programmed learning techniques should be followed for training and self-education of these workers. Programmed learning meterials for different trades can be prepared under the initiative of NCSDT.

5. Evaluator's guide-book and learner's primer should be developed for different trades to standardise the appraisal process.

6. Vocational guidance cell should be established at the district level offices of BMET to guide school dropouts into proper vocation. A detail survey of the requirements in each trade skill should be done for this purpose and updated time to time.

6.3 SCOPE OF FURTHER WORK

1. Quantification of the various elements or sub-matter mix in the NCDST standards for semi-skill and full-skill levels (given in appendix - C) for different trades.

2. Construction of specific application models for different trades from the generalised model.

3. Comparison of the elements in the NCDST standards with the elements and rating as per the proposed model for determination of equivalent qualifying limits for the application models of different trades.

REFERENCES

1. Harbison, Frederick & Myers, Charles A: Education, Manpower and Economic Growth, Oxford & IBH Publishing Co., New Delhi, Indian Edition, 1970, P-90.

2. Orleans, Leo A: Professional Manpower and Education in Communist China, 1960 P-25.

3. David, Henry : Education and Manpower, National Manpower Council, Columbia University Press, New York, 1960, P-144.

4. Coombs & Ahmed: Role of Non-formal Vocational Education in Rural Development, Proceedings of the International Conference at A.I.T, Bankok, 1977, P-516.

5. Mahmud, Iqbal: Technology Policies and Planning, Bangladesh, Asia & Pacific Centre for Transfer of Technology, Bangalore, 1986, P-36,47.

6. B.M.E.T.: Handbook of Information on Training Activities, B.M.E.T; Proshikhan Bhaban, Dhaka, 1987, P-3,4

7. Thondike, Edward L: Mental & Social Measurements, Teacher's College, Columbia University, 1912, 2nd Edition, Ch-2.

8. Travers, Robert M.W & Gronhund, Normán E: Meaning of Marks, Journal of Higher Education, 1950, quoted from book mentioned in serial-9, P-369.

9. Ebel, Robert L: Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-397.

10. Thorndike, Edward L: Quoted in Ebel's Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-20.

11. McCall, William A: Quoted from Ebel`s Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-20.

12. Ebel, Robert L: Wlritting the Test Item, Educational Measurement, ed. E.F. Lindquist, American Council of Education, Washington D.C, 1951.

13. Thorndike, Edward L: Quoted from Ebel`s Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-57.

14. Davis, Frederick B: Quoted from Ebel`s Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-346.

15. Ciardi, John: Quoted from Ebel`s Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-149.

16. Nathan, A Womack: Quoted from Ebel`s Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-V.

17. Webster Dictionary: 3rd Edition.

18. Sheal, Peter R: How to develop and present Staff Training Courses, Kogan Page, London/Nichols Publishing, New York, 1989, P-11.

19. Gauge, Robert M: The Conditions of Learning, Holt, Rinehart & Winston, 1985, P-2.

20. Kidd, J.R : How Adults Learn, Cambridge Publishers, 1973, P-24.

21. Kolb, David : Learning Style Inventory McBer and Company, 1976, P-32.

22. Buzan, Tony : Use your Head, BBC Publications, 1974, P-49.

23. Roger, Carl: Quoted from Sheal`s How to develop and present Staff Training Courses, Kogan Press, London, 1989, P-27.

24. Thurstone, Louis L: The Improvement of Examinations, American Association of University Professors Bulletin, June, 1984.

25. Likert : Statistical Methods in Psychology, P-678

26. Olt: Quoted from Environmental Indices Theory and Practice, Ann Arbor Science Publishers; Inc., Michigan 1978.

27. Ebel, Robert L: Measuring Educational Achievement, Prentice Hall of India, New Delhi, 1966, P-450.

28. Hamelick, Jack and Hamelick, Jerry, Training & Development Journal, October, 1980, Vol-34, No.11. American Society for Training and Development P-88.

29. Mager, Robert F: Preparing Instructional Objectives, Pitman Learning, 1984, P-5.

30. Islam,A.K.M.Rashidul & Azim, M.Anwarul: Software Technology Input in Dholai Khal Industries, an unpublished research paper,I.P.E,BUET 1987.

31. Hoffer, Eric : The True Beleiver,Harper & Row, Publishers Inc. New York, 1951, P-59.

Other References.

32. Sharif M N & Sundarajan V: A Quantitative Model for the Evaluation of Technological Alternatives, Technological Forecasting and Social Change, Vol-24, 1983.

33. Portal et al: A Guide-book for Technology Assessment and Impact Analysis, Elseiver, North Holland, New York, 1980.

34. King, Kenneth: Technological Capabilities in the Third World, Macmilan Press, London, 1984.

35. Pandit H.N: Measurement of Cost, Productivity and Efficiency of Education, National Council of Educational Research & Training, New Delhi, 1969.

36. Sing, Gajendra & Goede. J.H: Proceedings of International Conference on Rural Development Technology, An Integrated Approach at A.I.T, Bankok, 1977.

37. Satty, T.L & Rogers P.C : Higher Education in the United States (1985-2000) Socio-economic Planning Science, Vol-10, 1976.

38. Allen, R.G.D : Index Numbers in Theory and Practice, Macmilan Press, U.K., 1975,

39. Baster, N : Measuring Development, Frank Cass and Co. London, 1972.

40. Islam, M Nazrul, The Process of Technology Assessment and Technology Diffusion, I.A.T. BUET, 1986.

APPENDIX - A

'CHECKLIST' FOR ANALYSIS OF THE TRADE OF 'TURNER'

1) Machine
2) Job
3) Tool
4) Job-Tool
5) Measurement
6) Drawings

(1) MACHINE can be classified under the following sub-groups : knowledge about'

i) Parts
ii) Attachment
iii) Processing
iv) Setting up
v) Size/capacity
vi) Types.

(i)'Parts': can be considered to consist of the following elements.

1) Bed
2) Head stock
3) Tailstock
4) Carriage Assembly :

   1) Carriage
   2) Apron
   3) Cross-slide
   4) Tool post

5) Quick change gear-box
6) Main spindle
7) Feed shaft
8) Lead screw

ii) 'Attachments': can be considered to consist of the following elements.

1) Threading Dial
2) Work holding devices

i) Independent chuck
ii) Self centering chuck
iii) Collect check
iv) Carrier plate

3) Mandril
4) Steadies

i) Steady rest
ii) Follower rest.

5) Face plate
6) Centres

i) Fixed
ii) Revolving
iii) Half

iii) 'Processing Types': are the following :

Type	Knowledge Required
1) Face turning	: vel, centre, tool, tip position.
2) External and Internal Cylindrical grinding	: job/tool position, velocity, feed, tool, holder.
3) Taper turning	: taper standards, ratio, angle, velocity, feed, surface finish.
4) Reaming	: types of reamer, reamer geometry, holders, axis alignment, velocity, feed, fits and tolerance.
5) Groving/Notch	: tools, sequence of tool and operation, depth of cut, angle.
6) Parting off	: tools, job/tool position, velocity, feed, depth of cut.
7) Centre drilling	: centre location, velocity, depth of cut
8) Drilling	: tool, velocity, feed, tool geometry.
9) Thread turning	: thread standards, setting, depth of cut, feed, tools, taps, die.

10 Champering : depth of cut, champer setting.

11) Form turning : geometry, angle, tools, feed, sequence depth of cut, radius.

iv) 'Setting Up': the following skills are essential.

1) Mounting of tool
2) Clamping
3) Speed,feed and depth of cut setting
4) Champer setting/special attachment setting.

v) 'Size/capacity';based on the following elements:

1) Swing
2) Maximum work length between centres
3) Maximum chuck dia
4) Maximum speed
5) Maximum feed.

vi) Types of centre lathes

1) based on drive system

i) Step-cone pulley drive
ii) All gear drivce

2) based on tools-feeding

i) Speed lathe
ii) Engine lathe

3) others

i) Automatic lathes
ii) Special purpose lathes
iii) NC + CNC lathes

(2) JOB : the following sub-group
of knowledge can be identified.

i) Form
ii) Dimension
iii) Material
iv) Finish.

i) **Form** **Knowledge Required**

1) Cylindrical : length, radins, circle
2) Rectangular : length, flatness
3) Hexagonal : length, distance across flats.
4) Barrel: curvature < concave, convex radias
5) Conical : circle, angle, length
6) Threaded: standard threads, section, angle, helix
7) Curvature: radius
8) Keyways : length, section.

ii) Dimension

1) Length
2) Radius
3) Angles
4) Fits
5) Tolerance
6) Taper-ratio

iii) Material

1) Raw material:

i) State of matter, expansion of matter etc.
ii) Blowholes, defects
iii) State of heal treatment

2) Metals:

i) Cast iron ii) Steels (iii) Copper
iv) Brass (v) Aluminium (vi) Alloys
vii) Plastics.

3) Properties:

i) Machinability
ii) Hardness
iii) Ductility
iv) Brittleness
v) Toughness

iv) Finish: Tolerance, surface finish, thread finish, field of tolerance.

(3) TOOL : has the following sub-groups

i) Style
ii) Shape
iii) Geometry
iv) Material
v) Criteria for Resharpening

i) Style

1) Single point,

i) Solid tool
ii) Bit tool
iii) Flash butt welded tool
iv) Throw away tip tool
v) Brazed tip tool

2) Multiple point

i) Taper shank
ii) Straight shank

ii) Shape
Based on international Standards Organisation classifiction (ISO)

1) Single point

i) Bar turning tool
ii) Cranked turning tool
iii) Cranhed finishing tool
iv) Recessing tool
v) Cranked eacing tool

vi) Cranked knife tool
vii) Parting tool
viii) Boring tool
ix) Boring and facing tool

2) Multiple points

i) Drills:

a) Twist
b) Countersuch
c) Counter bore
d) Centering

ii) Forming tool
iii) Thread cutting tool
iv) Knurling tool

iii) Geometry

1) Angles:

i) Back rake
ii) Side rake
iii) End relief
iv) Side relef
v) End cutting
vi) Side cutting edge
vii) Point
viii) Helix
ix) Chisel.

2) Cutting edges

i) End cutting edge
ii) Side cutting side
iii) Chisel edge

3) Nose :

i) Angle
ii) Radius of curvature

4) Faces & Flanks

5) Dimensions.

iv) Material

1) Plain carbon steel
2) Low alloy steel
3) High speed steel
4) Non-ferrous cast alloys.
5) Cemented carbide
6) Daimonds
7) Ceramics
8) Cermets.

v) **Criteria for Resharpening**

1) Flank wear
2) Face crater
3) Slipping of cutting edges
4) Dimensions
5) Loss of hardness.

(4) JOB/TOOL. : has the following sub-groups and elements:

1) Cutting variables
2) Culting fluids
3) Chips

i) **Cutting variables**

1) Speed : rpm, m/min
2) Feed : m/rev
3) Dept of cut: mm

ii) **Cutting fluids**

1) Coolant type: low viscosity, high conductivity, high heat capacity, non corrosive.

2) Lubricant type: with additional high lubricating property.

3) Sulpho chloriuated oils

iii) Chips

1) Types
2) Forms
3) Temperature effect
4) Breakage control & disposal.

1) Types :

i) Discontinuous
ii) Partially continuous
iii) Continuous
iv) Continuous with built up edge.

2) Forms :

i) Infinite helixes
ii) Open, intermittent coils
iii) Continuous spiral
iv) Close intermittent coils
v) Short well broken curls
vi) Flat open coils
vii) Medium open curls
viii) Serrated half turns
ix) Serrated ribbon
x) Continuous ribbon.

3) Temperature effect

i) Heat generation zones
ii) Cutting temperature
iii) Heat transfer.

4) Chip control

i) Modes and attachment
ii) Breakage and disposal

(5) MEASUREMENT & INSPECTION

Necessary elements can be grouped as below:

1) Angular measurement
2) Linear measurement
3) Non linear functions
4) Fits & tolerances
5) Surface roughness
6) Gages

i) Angular measurement

1) Degrees radians etc.
2) Tools :

i) Beval protactor
ii) Combination protactor
iii) Sine bar
iv) Dividing head
v) Angle gage blocks

ii) Linear measurements

1) Length or distance, depth, diameter
2) Tools :

i) Engineers rule
ii) Square head
iii) Centre head
iv) Callipers- Spring, joint
v) Vernier callipers
vi) Micrometer Screwgauge
vii) Height depth vernier/micrometer

iii) Non linear Functions:

1) Flatness
2) Roundness
3) Parallelism
4) Alignment

iv) Surface Roughness

1) Roughness height
2) Roughness width
3) Waviness height
4) Profilometer

v) Gages

1) Limit gages:

i) Plug gage
ii) Ring gage
iii) Snap gage
iv) Length gage

2) Non-limit gages

i) Radius gage
ii) Feeler gage
iii) Wire gage
iv) Hole gage

3) Form gages

i) Screw pitch
ii) Fillet
iii) Centre
iv) Drill Point
v) Angle
vi) Screw pitch

(6) DRAWINGS

necessary elements can be grouped as follows :

i) Plan
ii) Elevation
iii) Cross section
iv) Projection
v) Dimension
vi) Tolerence representation
vii) Representation of surface finish
viii) Graphs.

APPENDIX - B

QUESTIONNAIRE FOR OPINION SURVEY

(A) In trying to evaluate the professional knowledge of a turner the following factors have been identified :

1. Knowledge of Science

2. Knowledge of Technology

3. Productive Skills

Knowledge of Science has also been thought of to be composed of the different sub-factors and each sub factor of different elements.

Similar arrangements have also been thought of for Knowledge of Technology and productive skill factor and given in table below :

Please make a pairwise comparison of the three factors and the sub-factors under each factor considering importance of each relative to the others, using the following scale of relative importance.

Scale of relative importance :

1. Equal importance

3. Weak dominance

5. Strong dominance

7. Demonstrated dominance

9. Absolute dominance

2,4,6,8 : Intermediate value.

1. Comparison among different factors :

	Knowledge of Science	Knowledge of Technology	Productive Skills
Knowledge of Science			
Knowledge of Technology			
Productive Skills			

2. Comparison among different sub-factors of each factor:

Factor 1: Knowledge of Science

	Knowledge of Numeracy	Knowledge of Geometry	Knowledge of Drawing	Knowledge of Basic Science	Knowledge of Material Science
Knowledge of Numeracy					
Knowledge of Geometry					
Knowledge of Drawing					
Knowledge Basic Science					
Knowledge of Material Science					

Factor 2 : Knowledge of Technology.

	Job Setting	Tool Selection	Tool Setting	Speed Setting	Lathe Operation	Operation Sequence	Use of Gages	Tool Regrinding	Coolant Selection
Job Setting									
Tool Selection									
Tool Setting									
Speed Setting									
Lathe Operations									
Operation Sequence									
Use of Gages									
Tool Regriding									
Coolant Selection									

Factor 3: Productive Skills

	Reasoning	Confidence	Experimentation	Dissemination	Creativity
Reasoning					
Confidence					
Experimentation					
Dissemination					
Creativity					

B) Please identify according to hierarchy of importance (by placing, 1,2,3 ...... in order of importance) to the following elements of each sub-factors which you considered be relevant for the training or profession of a turner.

Sub-factor : Knowledge of Numeracy

Elements	Sl. No. (in order of importance)
Units of linear measurement	-
Units of angular measurement	-
Area	-
Volume	-
Decimels	-
Fractions	-
Ratio	-
Average	-
Percentages	-

If you like you may make any other comment or add any other item or items and please put your statement above and allocate the marks accordingly.

Similarly please make your gradings for the other sub-factor elements, given below :

Sub-factor : Knowledge of Geometry

Straight line	-
Curve	-
Traingle	-
Square	-

Rectangle	–
Circle	–
Angle	–
Radius	–
Polygon	–
Centre	–
Parallelism	–
Taper	–
Height	–
Cylinder	–
Conical	–
Threaded	–

Sub-factor : Knowledge of drawing

Plan	–
Elevation	–
Cross-section	–
Projection	–
Dimension	–
Tolerence	–
Representation or Surface finish	–
Graphs	–

Sub-factor : Knowledge of basic science

Mass	-
Time	-
Temperature	-
Force	-
Pressure	-
Voltage	-
Current	-
Resistance	-
Power	-
Specific gravity	-

Sub-factor : Knowledge of material science

States of matter	-
Expansion of matter	-
Physical properties of matter	-
Common working materials	-
Common Tool materials	-
Common heat treatment	-
Types of cutting fluid	-
Properties of cutting fluids	-

Please rate the different operations as given in the table in next page, by placing (1,2,3 ....) in order of importance against each sub-factors of the factor : Knowledge of Technology.

Comparision among the sub-factors of the factor: Knowledge of Technology.(compare the row-elements for every column)

Sub-Factors / Operations	Job setting	Tool selection	Tool setting	Speed setting	Lathe Operation	Operations sequence	Use of gages	Tool Regrinding	Coolant selection
1. Outside Rough Turning									
2. Outside Finish Turning									
3. Chamfering									
4. End facing									
5. Knurling									
6. Necking									

7. Drilling									
Boring									
9. External Taper turning									
10. Internal Taper turning									
11. External threading									
12. Internal threading									
13. Parting									
14. Key/ slot cutting									

APPENDIX - C

NATIONAL TRADE SKILL STANDARD

FOR TURNER (LATHE OPERATOR)

1. GENERAL PRINCIPLES:

1.1 This Trade Skill Standard is divided into three grades, grade I (the highest), grade II and grade III.

1.2 Persons who wish to be certified as competent in any of the three grades will be required to pay the appropriate fee and undertake a trade test designed to show by oral and/or written examination and by practical demonstration that they are in possession of the knowledge and skill set out in the Standard.

1.3 In all tests the following, where appropriate, will be taken into consideration :

1.3.1 The time taken to perform the test.

1.3.2 The method of work followed.

1.3.3 The finish obtained.

1.3.4 Regard for economy in the use of materials and care of equipment.

1.3.5 The observance of safety precautions.

1.4 Candidates who are successful in the trade test will be issued a certificate bearing their name and photograph and describing the grade they have attained in the Standard.

2. TURNER (LATHE OPERATOR) GRADE III :

Knowledge Requirements.

2.1 Mathematics equivalent to that required from a primary school graduate or machine shop mathematics related to the work of a turner (lathe machine) grade III.

2.2 Personal safety precautions in the use of tools, materials and equipment.

2.3 Simple measuring using a steel rule, inside and outside callipers and vernier calliper.

2.4 The reading and interpretation of sketches and mechanical drawings of simple machined parts.

2.5 An understanding of the machining characteristics of metals commonly used in the machine shop.

2.6 The identification of the thread form of vee, square and Acme threads.

2.7 Principal parts of a lathe and their functions; essential lubrication points on a lathe.

2.8 An understanding of clearance angles for cutting tools.

2.9 Three-jaw, four jaw and collet-type chucks.

2.10 The use of tables for selection of drill tapping sizes.

Skill Requirements

2.11 Ability to work to tolerance of + 0.010 inch (0.25 mm) and to a surface texture of 125 micro-inches CLA (125 Ru Metric Units) on a lathe.

2.12 Taking and laying out measurements using rule, callipers, dividers and vernier calliper.

2.13 Sharpening high speed tool bits and drills.

2.14 Alighning lathe centres.

2.15 Centering in a four-jaw chuck using a surface gauge.

2.16 Turning and boring a simple workpiece.

2.17 Cutting single entry Vee form threads, internal and external.

2.18 Facing to parallel and to thickness.

2.19 Knurling.

2.20 The use of taps.

3. <u>TURNER (LATHE OPERATOR) GRADE II</u>:

<u>Prerequisite</u>

3.1 Candidates for certification must have passed the trade test for turner (lathe operator) grade III.

<u>Knowledge Requirements</u>

3.2 Machine shop mathematics related to the work of turner (lathe operator) grade II.

3.3 Use of tables for selection of cutting speeds.

3.4 The working principles of dial indicator and the micrometer.

3.5 Selection of cutting tools for various operations.

3.6 Selection of gear trains for required turning and thread cutting speeds.

3.7 The reading and interpretation of mechanical drawings of limited complexity.

Skill Requirements

3.8 Ability to work to tolerances of + 0.002 inch (0.05 mm) and to a surface texture of 63 microinches CLA (63 Ra Metric Units) on a lathe.

3.9 Using Vernier callipers, micrometer and dial indicator.

3.10 Grinding of tools commonly used on a lathe.

3.11 Using the steady and follower rest.

3.12 Taper turning using the taper turning attachment and offset tailstock method.

3.13 Screwcutting single entry square and Acme threads, internal and external.

4. TURNER (LATHE OPERATOR) GRADE I:

Prerequisite

4.1 Candidates for certification must have passed the trade test for turner (lathe operator) grade II.

Knowledge Requirement

4.2 Machine shop mathematics related to the work of a turner (lathe operator) grade I.

4.3 Calculation of thread dimensions.

4.4 The basic concept of fits and tolerances.

4.5 Surface finish of machined parts.

4.6 Reading and interpretation of mechanical drawings.

4.7 Planning a job.

4.8 Basic properties of the usual materials subjected to lathe operations.

4.9 Lathe attachments and their uses.

4.10 Feeds and speeds for different lathe operations.

Skill Requirements

4.11 Ability to work to tolerances of + 0.0005 inch (0.01 mm) and to a surface texture of 32 micro-inches CLA (32 Ru Metric Units on a lathe.

4.12 Turning eccentric diameters, external and internal.

4.13 Mounting and balancing work on a face plate.

4.14 Screw cutting multi-entry threads.

4.15 Reaming.

4.16 Turning profiles.

4.17 Cutting single-entry Vee form tapered threads, internal and external.