

**A CLASSROOM-BASED INVESTIGATION INTO
THE POTENTIAL OF A COMPUTER-MEDIATED
CRITERION-REFERENCED TEST AS AN
EVALUATION INSTRUMENT FOR THE
ASSESSMENT OF PRIMARY END USER
SPREADSHEET SKILLS.**

THESIS

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ABSTRACT

The demand for innovative end users of information technology is increasing along with the proliferation of computer equipment within the workplace. This has resulted in increasing demands being made upon educational institutions responsible for the education of computer end users. The demands placed upon the teachers are particularly high. Large class groups and limited physical resources make the task especially difficult.

One of the most time consuming, yet important, tasks is that of student evaluation. To effectively assess the practical work of information technology students requires intensive study of the storage media upon which the students' efforts have been saved. The purpose of this study was to assess the suitability of criterion-referenced testing techniques applied to the evaluation of end user computing students. Objective questions were administered to the students using Question Mark, a computer-managed test delivery system which enabled quick and efficient management of scoring and data manipulation for empirical analysis.

The study was limited to the classroom situation and the assessment of primary spreadsheet skills. In order to operate within these boundaries, empirical techniques were used which enabled the timeous analysis of the students' test results. The findings of this study proved to be encouraging. Computer-mediated criterion-referenced testing techniques were found to be sufficiently reliable for classroom practice when used to assess primary spreadsheet skills. The validation of the assessment technique proved to be problematic because of the constraints imposed by normal classroom practice as well as the lack of an established methodology for evaluating spreadsheet skills. However, sufficient evidence was obtained to warrant further research aimed at assessing the use of computer-mediated criterion-referenced tests to evaluate information technology end user learning in situations beyond the boundaries of the classroom, such as a national certification examination.

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1 INTRODUCTION

The use of information technology has grown noticeably over the past decade. Personal computers are regarded as standard tools within the work place and in many instances the home as well. However, as with any tool, the question must be asked whether or not information technology is being used optimally by the end users.

The end user of technology is a complex being to define, considering the vast spectrum of computer technology applications within industry. Not all users of computers have the same needs. On the other hand, considering the size of the investment being made in information technology, can it be tolerated that the users of this equipment do no more than execute a number of routine keyboard operations with no innovative use of the technology being made throughout their economically active life-span?

From a strategic point of view it would seem reasonable to expect the users of information technology to develop to their full potential in the use of the equipment so as to be able to function optimally within the work place. Computer end user education is offered at many tertiary institutions in order that graduates may be information technology literate when entering the job market. On the other hand, continuous computer training is a booming industry within the private sector. A common difficulty experienced by these differing educational institutions is that of cost effective student evaluation in order to assess whether or not a student has attained an acceptable level of competence in the appropriate computer usage.

The demands being made upon the resources of training and education institutions are ever increasing. As a result of this, teaching staff are hard pressed to maintain the academic administration required in order to develop, present and maintain such courses. Testing is particularly difficult in the field of end user computing

since in order to assess a student's efforts effectively, the actual files on the disks must be examined. Where class groups are large in number, this can become an invasive activity in the sense that teachers may spend the majority of their time 'marking' rather than getting on with the business of teaching. It could even result in the students not being effectively evaluated at all; hardly a satisfactory situation.

The purpose of this study is to investigate techniques which can be used in order to assess the learning outcomes of students attending computer end user courses. An assessment instrument is needed which will:

- be administratively economical
- enable the quick and effective collation of the students' responses for further analysis
- be an acceptable evaluation delivery medium to the students who are being assessed
- be reliable and valid.

Although the long term goal of a national end user education strategy is identified as being essential in order to develop an efficient, information technology literate work force, the focus of this study will be upon the classroom situation. It is within the classroom where the building blocks of national strategies are laid. Furthermore, since end user computing is a vast field, the evaluation techniques discussed in this study will be applied to the assessment of primary spreadsheet skills only (see 3.5.1).

Therefore, the assessment instrument to be created will be designed to assess end user computing skills within the classroom. The reliability and validity testing will be carried out within the boundaries experienced by classroom practitioners. The results of this investigation will determine whether or not the assessment tool developed is worth further investigation with a view to it being used to assess

other facets of end user computing in a wider context than the normal classroom situation, such as national certification examinations.

2 LITERATURE STUDY

2.1 INTRODUCTION

End user computing has been the focus of many studies during the past decade. In terms of the number of end users of information technology, there has been enormous growth, especially during the latter half of the 80's (Amoroso, 1988: 50). Some of the reasons which account for this prolific growth include the reduction of the applications backlog as well as a reduction in maintenance requirements for existing systems on the part of the Information Systems Department (Senn, 1990: 767 - 768). Another major contributing factor to the growth of end user computing is the availability and reducing costs of microcomputers and accompanying fourth generation software.

The literature studies carried out on this issue emphasize that end user computing cannot be ignored. Not only because of its growth but because of the strategic value successful management of end users can bring to the organization in which they function (Nelson, 1989: 2). Many tertiary education institutions commit a large percentage of their capital and human resources to the training and education of information technology end users. However, the growth in demand for end user training courses within the formal curricula has resulted in these resources being overburdened; especially the human resource. This is the most expensive resource to provide and hence the one requiring the most justification on the part of those requesting more staff to do the job. While this may seem shortsighted it is nevertheless very difficult to offer a cost related justification for the need of more information technology end user educators. Gerrity and Rockart (*in* Amoroso, 1988: 54) "conclude that the real value of end-user computing cannot be readily justified in terms of initial payoffs and performance". They make a case that "end user computing brings real leverage to the organization in terms of external competitive advantage and internal organizational effectiveness". When the implications which this statement has for a national information technology policy

are considered, it becomes imperative that institutions responsible for end user education use their resources optimally in order to achieve the goal of fostering an information technology literate workforce.

2.2 PROFILE OF AN END USER

To limit the term 'computer end user' to a particular type of employee or social status would be an error. Information technology end users come from all walks of life and their needs therefore differ with respect to their level of use of technology as well as the way in which the technology is applied. What is important, however, is that information technology end users become innovative workers in that they not only act as receivers of information but that they have the ability to use it strategically (Senn, 1990: 6).

Table 2.1 CATEGORIES OF END USERS [ROCKART AND FLANNERY (IN AWAD, 1988: 332)].

CATEGORY	DESCRIPTION
Non-programming End Users	Access data by means of applications developed by others
Command Level Users	Access data by performing inquiries on their terms. They may generate reports using 4GL report generators but will only learn enough in order to satisfy their own immediate needs.
End-User Programmers	Develop their own applications, which are intended for their own information needs, using both command and procedural languages .
Functional Support Personnel	These users are sophisticated end users who give support to other end users within a specific functional area such as marketing or financial analysis.
End-User Computing Support Personnel	Sophisticated end users normally located within an information centre. They are skilled in end user languages and can develop applications and offer support in various application packages.
DP programmers	Programmers using end user languages.

An erroneous view of an end user would be to consider such a person as being a 'hacker' or mere computer operator. Much attention has been paid to the classification of end user skills levels and categories of end users. Rockart and Flannery (in Awad, 1988: 332) identify six levels of end users described in Table 2.1.

Panko (1988: 167 - 172) has suggested a skills hierarchy which can be used as a guide in mapping the development of the end user. These ideas are summarized in Table 2.2.

Table 2.2 THE SKILLS HIERARCHY [PANKO (1988: 167 - 172)].

SKILL LEVEL	DESCRIPTION
Basic Use Skills	Limited understanding of the computer and its operating system and an introductory knowledge of an application software package.
Comfort Use Skills	Through use and experimentation the user becomes comfortable with the hardware and software and begins to develop patterns of use. Tips are learned from other users and advanced courses may be taken in the use of the operating system and application software.
Good Practice	Knowledge is required in order to use the computer efficiently and safely. Issues such as data management, application development and the ability to apply domain knowledge (financial concepts for example) are some of the issues of concern. Effective resource management is also a characteristic of good practice.
Innovation	This is the ability to implement change within the work place in order to gain the strategic advantage which can be realised through the optimal usage of Information Technology.

This proposed hierarchy needs consideration and is of particular importance to the education and training issues of end user computing. The ultimate goal, in terms of this proposal, is to empower all end users to the level of 'innovation'. In order to achieve this, educators and trainers have many hurdles to overcome. User

attitudes influence the level to which they develop [(Ein-Dor and Segev, 1991: 31); (George, 1991)] and very often *plateauing* occurs (Panko, 1988: 168). Plateauing can be defined as the situation where a user refrains from further training and is satisfied with an incomplete understanding of the hardware and software which enables short-term functionality. This is a factor which can hamper the efficiency of a corporate information system through injudicious manipulation of corporate data. Users of the future will be expected to function in a disciplined manner which affords the optimal functioning of a corporate information system (Craig, 1993). *Plateauing* will not foster such end user maturity.

What can be seen from the above is that a computer end user is a complex being who can be identified at many levels within an organization or society. The idea of end users being classified as simple keyboard operators must be rejected. It is in the best interests of any organization wishing to play a role in the emerging information based society that end users of information technology be encouraged to develop to their full potential.

2.3 THE STRATEGIC IMPORTANCE OF END USER COMPUTING

The value of an innovative end user population is not measurable in monetary terms but rather in improved decision-making (Amoroso, 1988: 53), enabling employees to participate in the maintenance of strategic advantage at all levels of the organization. The end user is often the interface responsible for successful interaction of an organization's information system with the environment in which it functions (see Figure 2.1).

This is particularly important when considering an economic strategy at a national level. The end user is an essential resource for any country to be able to participate within the global economy. There is certainly concern being expressed as to "how are countries approaching the problems of the widespread and effective absorption of the information technologies?" (Goodman, 1991: 19). There is a threat that

certain countries not in a position to implement information technology successfully may be marginalized from the global economic structure which is developing. A key resource is the quality of information technology end user skills available within any country.

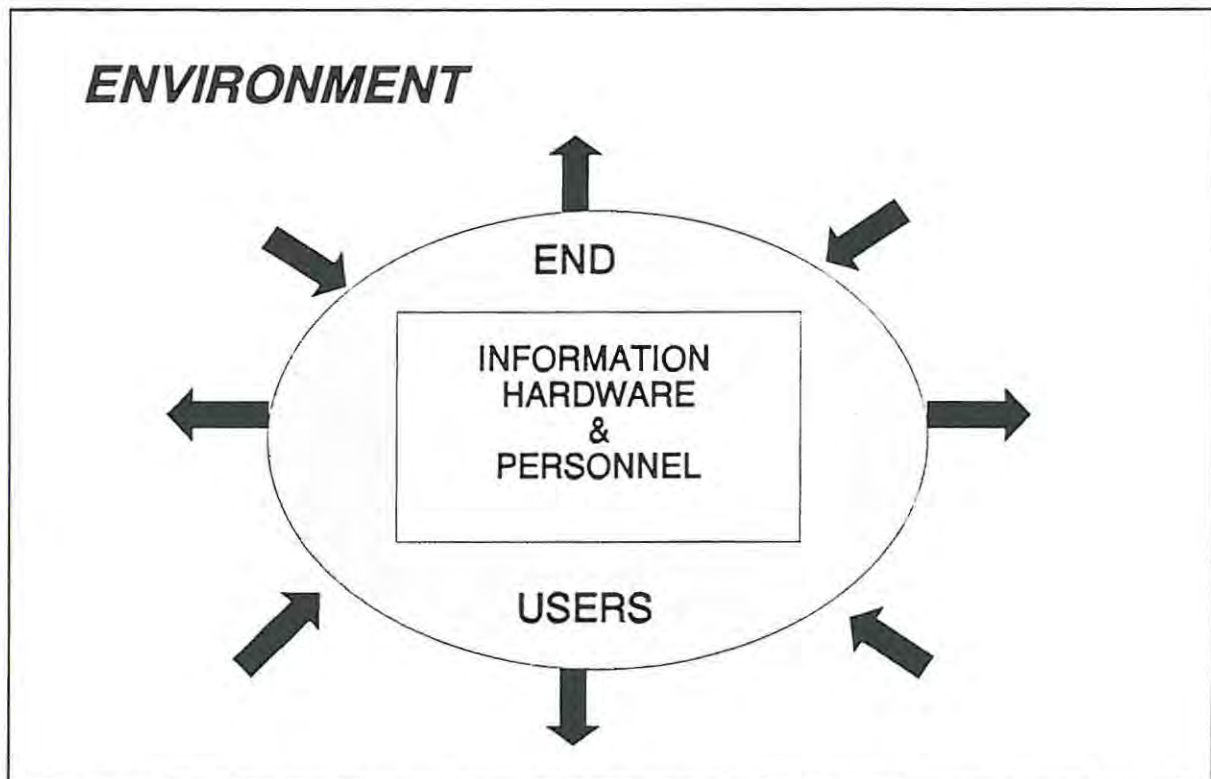


Figure 2.1: THE END USER AS INTERFACE BETWEEN THE ORGANIZATION'S INFORMATION SYSTEM AND THE ENVIRONMENT WITH WHICH IT INTERACTS

2.4 THE ROLE OF INSTITUTIONS RESPONSIBLE FOR END USER EDUCATION

2.4.1 The Types Of Institutions

It is important for us to understand which are the institutions responsible for end user education. The researcher wishes to stress that it is not only tertiary education institutions which have this responsibility.

There are many institutions in the private sector which conduct end user training/education either as an in-house service in order to improve the work force, or as a commercial venture by providing a service to other companies. All of the players mentioned have an important role to play considering the strategic importance of the computer end user which was described in paragraph 2.3 above. Not one of these players should seek the exclusion of any other since the demand for **effective end user education** far outweighs the supply of such education. This has been highlighted by Raymond (*in* McDougall, 1990: 471) who makes specific reference to the under-utilization of information technology by executives because of a lack of appropriate skills. End user computing educators in Singapore recognise this shared responsibility amongst the different institutions and actively seek to engage them in achieving their national information technology goals (Goh *in* McDougall, 1990: 522). The major importance is that all of these players recognise the need for standards to be met and that a common goal is strived for in order that the end product of their teaching programme is an **innovative end user**.

2.4.2 Specific Responsibilities

It would seem, in the light of what has been said in the previous paragraphs, that the ultimate goal of the institutions responsible for end user education is to educate the end user toward becoming an 'innovative user' of information technology. However, as pointed out by Davis (1993: 61), it is not yet clear as to how this goal is achieved. There does not seem to be an encompassing didactic strategy at the disposal of end user educators which will guarantee the fostering of innovative users. This places greater emphasis on the need for institutions involved in end user training to participate in educational research within this field. For the moment, however, there are specific responsibilities which end user training institutions must be held accountable for:

- educators

- course materials

- liaison
- educational research

These areas of responsibility will be discussed below.

2.4.2.1 Educators

It is vital that the 'educators' responsible for end user education are skilled not only in the information technology skills required but also the current didactic skills which have been identified as being acceptable (Goh *in* McDougall, 1990: 522). Furthermore, Nydahl (*in* McDougall, 1990: 557) stresses that the teacher must be able to guide the student in the application of information technology in various vocational settings. It is not sufficient that computer skills are learned in an isolated setting since this will reinforce the idea of computer skills being acquired as an end in themselves.

It is the researcher's view that the institutions employing educators responsible for end user computing are obliged to contribute to the professional growth of their employees in order to ensure that meaningful transfer of learning takes place between educator and educand. This means that the institutions are responsible for the cultivation of technical and educational skills as well as vocational diversity within their teachers responsible for the education of end users of information technology.

2.4.2.2 Course Materials

A tacitly implied quality of an innovative end user is the ability to read and use software manuals in order to solve personal computing problems. Therefore, course material must be provided to the learner which will foster the ability to consult and understand computing literature. Furthermore, course materials should be liberating in the sense that they enable the learners to adapt the skills acquired to the

environment in which they function (Goh *in* McDougall, 1990: 523). Because of the vast number of application packages used within industry, it is not always possible for the end user to be exposed to identical applications within the work place and the institution attended. Therefore, course material must be generic in design and facilitate transfer between applications.

2.4.2.3 Liaison

In order for different types of institutions to work towards a common goal, being that of meeting the national need for innovative end users, there must be a working harmony between them (Goh *in* McDougall, 1990: 522). However, this calls for a coordinating body at national level which adheres to national information technology education policy [(DeMichiell, 1990), (Plomp *in* McDougall, 1990), (Nydahl *in* McDougall, 1990), (Goh *in* McDougall, 1990)]. Where such a body does not yet exist, it is the responsibility of the institutions of that country to create or call for the creation of such a body to develop a national policy which is essential for the attainment of common standards.

2.4.2.4 Educational Research

Until more is known about the actual didactics of end user training which foster end user maturation in the use of information technology [(Amoroso, 1988: 50); (Nelson, 1991: 507); (Sein *in* Nelson, 1989: 137); (Panko, 1988: 172); (Davis, 1993: 61)], strategies which appear to contribute positively must be reported and subjected to rigorous research for further validation. In this regard, tertiary education institutions involved in end user training are particularly well placed because of the volume of students per annum as well as the diversity of students requiring end user skills. However, they should not be expected to conduct such research in isolation. Support should be given by all the institutions and governing bodies responsible for the education of end users of computer technology.

2.5 EDUCATION STRATEGIES

End user education and training is cited as being a critical issue throughout the literature and yet very few studies have been carried out in order to assess and improve existing strategies or develop new ones [(Amoroso, 1988: 50); (Nelson, 1991: 507); (Sein in Nelson, 1989: 137); (Panko, 1988: 172); (Davis, 1993: 61)].

If we accept Panko's hierarchy of skills, which was discussed earlier in Table 2.2, then our goal must be to educate end users to become innovative. This would seem to be in agreement with Nelson (1991: 505) who points out that "education teaches problem solving approaches while focusing on the ability to reason abstractly. Training, on the other hand, provides the tools (i.e. skills) for implementing problem-solving approaches while focusing on the ability to work concretely." If we are to foster an innovative end user population then training will not be enough in order to develop an end user to the full potential, namely, 'an innovative end user'. The importance of this being that for economic growth to occur, workers must be empowered to recognise strategic advantage at whatever level they may be within the economy and seize it. This will mean that end users must have the ability to identify concrete advantages which may be abstractly represented through information technology. They must be educated rather than simply trained in the operational skills of technology usage.

Studies carried out in the field of end user education have been conducted mainly by scholars of Management Information Systems. This has resulted in the focus of such studies being placed more upon the affective outcomes of education and training such as attitudes towards computer usage rather than proficiency in the use of this technology. One such study found that there was no significant difference between a trained end user and one that had not been trained (George, 1991). However, this study was conducted within a single company where all staff received the same training! The lesson to be learned from this is that we need to be able to analyse end user education and training in order to assess whether such courses are of value or not. A model must be developed which can be used as a

guide for the development of effective end user training courses which foster innovative users.

Panko (1988: 170) drew our attention to the importance of domain knowledge being incorporated in end user education and training. Nelson (1991: 505) takes this point even further when he considers what mix of organizational and information technology skills are required to enable end users to function at an optimum level within the organization in which they are situated. Limited information technology skills result in applications developed by such users being naive and lacking in continuity and integrability (Raymond, 1990: 22). There are risks involved in end user computing which must be addressed; data integrity and reliability to mention just two. Application generators such as CLARION are readily available to end users and with the downloading of data from host computers to micro computers, these principles can be violated unless the end user is *au fait* with the database doctrines of normalization or entity relationship design.

Considering the previously described strategic importance of end user computing, it is vital that institutions responsible for such education ensure that their courses foster the growth of a national information technology human resource. "It is imperative that as educators, we assess the directions defined by science and global information and communications resources if we are to compete in an increasingly competitive and global economy" (Thornborough *in* McDougall, 1990: 923).

The pressing demand for formal end user education (Raymont *in* McDougall, 1990: 471) has placed the resources of institutions responsible for end user education under a considerable amount of strain. However, when considering the profile of an innovative end user which was previously described, increased resources alone will not solve the problem. Innovative education strategies must be examined and implemented. The researcher wishes to draw the reader's attention to four approaches which have been used in end user education being:

- instruction based

- exploration based
- domain referenced and
- isolated.

2.5.1 Instruction Based Approach

In this approach, the learner is subjected to a teacher managed classroom situation at all times. The teacher is in full control of the pace and content of the learning and hence the course has a temporal constraint placed upon it according to the availability of the tutor. This is a common approach used in end user education [(Goh in McDougall, 1990); (Davis, 1993)].

2.5.2 Exploration Based Approach

The researcher defines this approach as being one where the student receives clear guidance from the tutor but is permitted to work on a computer freely without temporal constraints. This approach, which is also widely used (Davis, 1993), places the student in full control of the machine and his learning experience.

2.5.3 Isolated Approach

While the previous two approaches refer to the mode of delivery of end user education, consideration must be given to the contextual placement of this learning.

In the isolated approach, end user education takes place as a free standing subject isolated from any vocational or practical setting. This is the prescribed setting of end user education within South African Technikons. The subject "end user computing" exists as an independent module for which students register. It has no linkage with any other subject in the curricula of these institutions. The danger of

this is that the student can perceive the computer as an end in itself and not as a tool for problem solving and management of information related to his vocational setting (Collis, 1989: 80).

2.5.4 Domain Referenced

In the Domain Referenced approach, the computer is used as a tool in support of problem solving and information management within the curriculum. Computer education literature is well endowed with examples of computer software, spreadsheets in particular, being applied to many subject areas [(Przasnyski, 1989); (Ramadurai, 1991); (Turner, 1988); (Talib et al., 1989); (Pinter-Lucke, 1992)]. Panko (1988: 170-171) points out that one of the most important criteria for end user education to lead to what he terms "good practice" (see Table 2.2), is that such courses should include domain knowledge. When applications such as spreadsheets are being used within a particular domain, inventory management for example (Przasnyski, 1989: 121-125), the user must be in command of the domain knowledge required in order to do the task as well as the computer application knowledge.

End user computing, when considered from this perspective of being 'domain referenced' should not exist as an isolated formal subject, as is the case with South African Technikons. End user education should, under these circumstances, take place within other modules of the curriculum where the student will learn how to incorporate the computer into his daily vocational tasks as a natural extension of his problem solving thought processes. Davis (1993: 63) remarks that "*Meaningful learning* occurs when an individual connects information in a non-arbitrary and substantive manner with knowledge that already exists in memory." It seems reasonable that the student's learning of information technology will be more meaningful when he can relate it to other existing skills and knowledge rather than as an isolated module within the curriculum (Nydahl in McDougall, 1990: 557).

2.6 ASSESSMENT OF LEARNING OUTCOMES

Regardless of which tutorial strategy is adopted, the measurement of learning outcomes remains a key issue. At present, techniques of measuring student proficiency in the use of end user computer applications are not well established. This is one of the chief problems experienced by the coordinators of the programme initiated in Singapore which is aimed at educating the office workers in the use of Information Technology within that country (Goh *in* McDougall, 1990: 526). In many cases, certificates of attendance are issued to students as evidence of having completed an end user computing course. The certificate which is issued on the basis of attendance is not a measure of proven competence since no formal evaluation of the student's learning while attending the course has taken place. Physical attendance on the course is the only criterion which must be satisfied in order to be awarded such a certificate.

Formal educational institutions tend to assess the students on the basis of their ability to perform a set of tasks successfully. Anderson (1993), a tertiary educator, states that " ... there is a very simple final exam in my course: you have one hour... Either you can, or you can't." Davis and Bostrom (1993: 70 - 72) used this approach within a highly controlled laboratory experiment in order to assess end user learning outcomes. Students had to perform specific tasks which were recorded on diskettes. These diskettes were then scrutinized individually by a panel of assessors and scored.

The difficulty with this mode of student assessment is that in terms of man-hours, it is a very expensive exercise. It takes time to load each disk individually, access the data file and then begin to assess the student's work. Furthermore, there is the problem of inter-rater and intra-rater reliability. Davis and Bostrom (1993: 72) achieved a very high level of inter-rater reliability in their experiment. However, the nature of the tasks being assessed, operating system commands, enabled them to set very narrowly defined tasks. When tasks such as constructing report forms using a data base management system are being assessed, the evaluation of

students' efforts becomes more intricate. Furthermore, only 10 students were assessed at any one time (Davis & Bostrom, 1993: 71). Considering 8 groups of students were used in the experiment, four hours were required simply to administer the test to all 80 students. No indication is given of the time taken to assess the completed tasks.

The approach indicated by Anderson has been used by the researcher as well. However, when class groups are in excess of 150 students, the size of the task and the necessity of producing feedback to students as timeously as possible can negatively influence the quality of the assessment. Furthermore, Goh (*in* McDougall, 1990: 526) calls for a 'level of competency' to be measured which can serve as an indicator to industry of the proficiency with which the student can function when using information technology. This is in conflict with Anderson's (1993) view of "you can or you can't."

The main problem with this technique of student evaluation, according to the researcher, is that of human resources. Course leaders are not able to administer the evaluation of large groups of students within a short time period. However, because of current economic constraints on academic institutions in South Africa, it is unlikely that this resource will be markedly increased within the near future. If this problem is analysed more closely, then the following issues arise which justify the search for an alternative evaluation method:

- students need more regular evaluation
- the administration of the tests is very time consuming
- it is not always possible to test all the work covered in this way
- because domain knowledge and application knowledge are so interrelated it is often not clear which is being tested.
- students need timeous feedback in order to assess their own progress and

confidence levels.

The entire educational process has been viewed as comprising of certain subsystems by some researchers. "The evaluation subsystem - generally tests - is of utmost importance because through it one can see how both the student and the instructor meet their specified goals" (Palumbo, 1989: 61). In order to assess the effectiveness of any educational strategy, a means of evaluation must be devised to measure the learning, if any, which has occurred. The researcher therefore proposes that before any didactic strategy is implemented, a technique for evaluating the end user skills of students should be developed. Once this is done, the increased or decreased learning experiences of the students as a result of innovative teaching strategies can be measured using a known and proven evaluation technique. Without such an evaluation subsystem, any changes made in the instructional subsystem would be suspect since there would be no reliable tool to measure the effect upon the performance of any of the actors in the educative situation (Palumbo, 1989: 66).

2.6.1 Criterion-Referenced Testing

A common call that seems to be made by both industry and end user education institutions, be they formal or informal, is that the 'competency' of the student in the use of information technology must be assessed. The problems experienced with the evaluation of lengthy student projects and tasks were highlighted in the previous section. However, when one considers that tasks, such as those set by Davis and Bostrom (1993: 71) or even Anderson (1993), consist of a number of highly specific operations which the student has to perform, criterion-referenced testing should be given some attention.

A number of definitions for criterion-referenced testing have been offered in the literature [(Berk *in* Walberg, 1990: 490); (Glaser & Nitko *in* Berk, 1984: 12)]. What is common to all of them is that the student's ability to master a number of tasks drawn from a well defined domain of such tasks is assessed (Black & Dockrell,

1984: 37). Furthermore, criterion-referenced testing would seem to be best suited to situations where the test items are short, objective and easily scored [(Martuza, 1977: 253 - 270); (Berk, 1984: 49 - 77); (McArthur, 1987)]. Besides the fact that such test items can be more efficiently assessed, the process of in-depth analysis of student achievement on individual items and hence tasks becomes more realisable [(McArthur, 1987); (Jaeger, 1987); (Hambleton in Walberg, 1990: 117); (Liefeld & Herrmann, 1990); (Harris & Subkoviak, 1986); (Subkoviak, 1988); (Brown, 1990)]. "The major advantage of criterion referenced tests is the opportunity they afford teachers and curriculum developers to interpret test results diagnostically" (Jaeger, 1987: 7).

Norm referenced tests are designed to produce a score which, when interpreted, will rate a student with respect to the performance of the group in which he is placed (Rahmlow, 1979: 10). However, as pointed out by Berk (1984: 9), it is often necessary to know what actual portion of a given domain of knowledge has been mastered by the student rather than the relative ability of the student within a given group. This is the situation with end user computing. It is of far more value to know what the actual ability of a student is in using a spreadsheet or a database than to know that this student performs better than a given percentage of the students in the group.

In the light of what has been said above, it would seem reasonable to investigate the applicability of criterion-referenced testing using test items which are objective and focused upon a well defined domain of tasks. This would, if successful, address the need for student assessment which indicates mastery of a set of tasks and the need for an assessment tool which can be easily administered.

2.7 COMPUTER ADMINISTERED TESTING

It was established in the previous paragraph that criterion-referenced tests using short objective questioning styles should be considered as an approach to assessing end user computing students. This, if shown to be an appropriate means

of evaluation, will enable standardized mastery levels to be set for accreditation purposes as well as provide a more easily administered form of testing. The administration of such testing is of particular importance.

The administration issue is an area which contributes to the load being placed upon the human resources available for end user education. If this burden can be reduced in any way which will enable more efficient utilization of the human resource in computer education, such an opportunity should be seized in view of the strategic value of the information technology end user.

Computer based testing enables the educator to devote more time to the construction of test items and analysis of student responses which would otherwise be spent on the assessment of student's test scripts (Plumly & Ray, 1989: 75). The 'marking' of the student's responses is mechanically conducted and with such speed that feedback to students can be immediate, and response on the part of the educator to situations where remedial tuition may be required can be expedited considerably (Palumbo & Reed, 1989: 61).

Bernt et al. (1990) found a link between lack of computer experience and resistance to computer based testing. This is a concern which should not be overlooked. However, in the context of the current study, the researcher wishes to point out that the students to be evaluated using computer based testing are in fact students of computer technology. Hands-on experience of information technology is an intrinsic part of their education. On the other hand, Liefeld (1990: 23) draws our attention to the positive attitude of his Consumer Studies students to this form of testing. Bugbee (1990: 87) found that, "In general, student performance on computer administered exams is as good as, if not better than, that on paper-and-pencil exams. Furthermore, students prefer computerized-exams because (a) they may take the exam when they believe they are ready for it and (b) they receive their grade (pass or fail) immediately upon completion of the test."

Considering the need for efficient student evaluation techniques in computer end user education and the findings reported in this section, it would seem reasonable

to investigate the suitability of using a computer delivery system for testing end user computing knowledge.

2.8 SUMMARY

End users of information technology form a strategic resource for the successful implementation of information technology within any organization or nation. Educators at institutions offering courses in end user computing should endeavour to ensure that their courses assist in the provision of **innovative computer users**. In order to meet this goal, courses should conform to the following criteria:

- the nature and content of course material should facilitate domain orientated learning
- the structuring of course modules should correlate with an end user hierarchy of skills
- the correct balance of organizational/vocational skills and information technology skills must be identified and maintained.

One of the constraints preventing these ideals from being attained is the imbalance between the demand for end user courses and the educational information technology resources available.

It is the researcher's opinion that the first problem to be addressed before any teaching innovations can be introduced to the end user computing instructional subsystem, is that of the evaluation subsystem. An effective means of assessing student competence in end user computing needs to be developed in order that changes in student performance as a result of instructional innovation can be measured. Furthermore, such an evaluation subsystem must afford the maximum opportunity for analysis of student performance while being as administratively

streamlined as possible.

Computer-based criterion referenced testing has been identified in this literature study as a possible solution to the evaluation problem. Criterion referenced testing, unlike norm-referenced which focuses upon a student's achievements relative to the group in which that student is situated, aims at determining whether or not the individual student has met the performance standard set by the educator. The fact that such a test can be administered using a computer means that the administration of student testing can be optimized. This would provide the end user computing educators with more time to be spent on the teaching of students and preparation of course materials needed for the fostering of innovative computer end users.

3. ORIENTATION TO THE PROBLEM

3.1 INTRODUCTION

The evaluation of student learning outcomes is an integral part of the education process. However, it is important that the administration of the testing not interfere with the progress of teaching. In the case of end user computing, where the viewing of the students' work is a dynamic process and not simply the assessment of a paper bound product, the effective use of time in the process of student evaluation is particularly important. While an optimal solution to this problem must be found, the reliability and validity of the testing instrument must not be compromised in any way.

3.2 ANECDOTAL OBSERVATIONS

The researcher has been involved with end user education for a number of years. During this time, a growing dissatisfaction with the evaluation techniques used in order to assess end user computing learning outcomes has resulted in this investigation.

Evaluation techniques, such as those described by Davis and Bostrom (1993) or Anderson (1993) (see paragraph 2.6), have been used by the researcher. However, the time required for the assessment of the work done by the students, especially where classes were in excess of 150 students, proved to be detrimental to the progress of normal teaching. Similar views have been expressed by Black and Dockrell (1984: 26). Furthermore, the time elapsed between the students actually writing the test and receiving feedback was often too long for immediate remediation to take place. The main task of a teacher is to teach. While evaluation of students is an integral part of that task, the administration of testing should not dominate the job description of the teacher.

Not only is the assessment of a test as described in paragraph 2.6 a lengthy process, but the actual 'writing' of the test on the part of the students is time consuming as well (Davis and Bostrom, 1993). In order that a group of students perform a meaningful task for test purposes using a spreadsheet, data base or even a graphics package, more time is required than is available within the normal class period. The situation is often different at private training institutions but time and physical facilities are very real constraints within the formal education institutions. The facilities available may be limited to forty personal computers. If a class of 160 students (which is not uncommon in South Africa) has to complete a 3 hour task, 12 hours are required for the administration of the test. If this has to be done while other classes make use of the laboratory then the logistical planning becomes difficult.

The researcher has observed some attempts which have been made in order to alleviate the problem of 'time usage'. While promising on the surface, closer scrutiny has revealed serious flaws in the validity of the assessment. In one particular situation, the teacher assessed only the printed product produced by students who were enrolled for a word processing module. The disks were not examined at all. A number of cases were identified where the printed product gave the impression that the students had a high level of proficiency in the use of a particular word processing package and a high mark was awarded. However, the corresponding files on the students' disks proved otherwise. Some of the errors identified were:

- hard carriage returns were used at the end of each line thus nullifying the wordwrap feature
- tabulation and indent commands were not used but enormous numbers of 'spaces' for such alignment instead
- even though the use of a table of contents generation tool had been taught during the course, such entries were made manually

- page numbers were hard coded into each page rather than dynamically defined in a header or footer.

Once the disks had been examined, it was established that many of the students who had been awarded a pass mark on the basis of their 'hardcopy' assessment knew very little about word processing.

Another such example was identified by the researcher while giving a course in the use of a spreadsheet. The traditional method used at the institution where the research took place, was to present the student with a template and a list of instructions. The instructions served as a 'guide' to the student in placing certain formulae in given cells. The student then had to perform functional tasks such as copy ranges from one location to another or format a range of cells to a specified number of significant figures. Upon intuitive reflection, the researcher is of the opinion that this test confined itself to the testing of operational tasks only. Spreadsheet logic did not seem to be assessed at all which was alarming since, as stated by Sein et al. (*in* Nelson, 1989: 146), "a spreadsheet is an analogy for a modelling language". Therefore, in the researcher's view, the 'traditional test', by ignoring the underlying logic and algebra of spreadsheet management, did not assess the skills required for modelling using spreadsheets. This is not in line with the previously established goal of end user proficiency, as described by Panko (1988: 167 - 172), being 'innovation'.

When the results of a particular group of students who completed this course and wrote a 'traditional test' were plotted on a graph (see Figure 3.1) using a frequency distribution, a very encouraging result was obtained. Of the 221 students, 110 were rated as having achieved 100% on the test. However, the researcher observed one of these students a week later. This student was attempting to enter one series of independent data readings with a corresponding dependent set of readings and then plot a line graph using this data. The student had no idea where to begin the task.

A formal report (Carland, 1988: 112) has been made of the devastating financial

consequences which have been experienced by American businesses through the improper use of spreadsheets by company executives. Millions of dollars were lost because of incorrect spreadsheet logic being used to model business situations. It would seem reasonable to expect that when end user courses are given, diagnostic assessment of the students' knowledge during and at the close of the course be carried out in order to contribute to the prevention of such disasters.

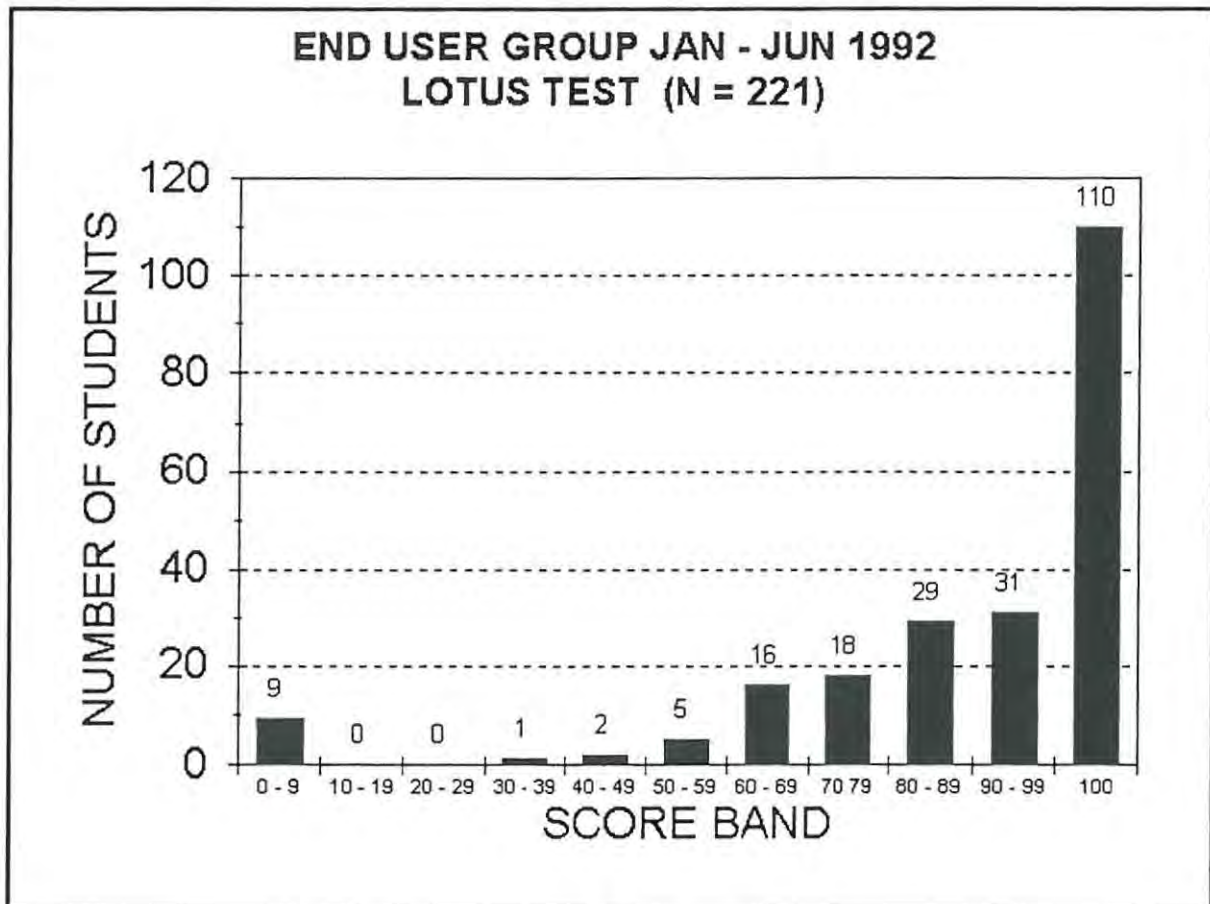


Figure 3.1 RESULTS OF THE TRADITIONAL SPREADSHEET TEST

3.3 STATEMENT OF THE PROBLEM

The need exists for a valid and reliable assessment tool for measuring end user computing learning outcomes. This tool must indicate whether mastery of the goals of the course has been met. Furthermore, the administration of this assessment tool must be efficient and afford the optimal use of time in the administration of

the test to the students and in the assessment of their work.

3.4 OBJECTIVES OF THE STUDY

The tacitly implied overall goal of this study is to propose a design protocol for a tool which satisfies the need raised in paragraph 3.3. Within the literature study of the previous chapter, it was established that computer administered criterion-referenced testing applied to the assessment of end user learning outcomes warranted further investigation (see paragraphs 2.6.1 and 2.7). Whether the use of these techniques would enable the realisation of the overall goal is dependent upon certain objectives being achieved when using these techniques. These objectives are:

- meaningful test design
- reliability and validity
- efficiency
- acceptability of the delivery medium.

3.4.1 Meaningful Test Design

The first objective is to design a criterion-referenced test that makes use of short items which can be administered within the framework of a suitable computer based test delivery system. These items must be piloted and analysed in order to assess their suitability to the domain which is being assessed as well as their ability to discriminate between those students who have mastered the work and those who have not.

3.4.2 Reliability And Validity

The test must be shown to be reliable in that it consistently classifies students as having mastered the work or not. Furthermore, the validity of the assessment tool must be examined. Reliability will not be sufficient evidence of the suitability of the tool for end user assessment since, if it is not valid, the tool could be reliably classifying students as having mastered work in a totally invalid manner. Examples of this were given in paragraph 3.2.

3.4.3 Efficiency

By using a computer based test administration package, our objective is to show that the assessment of students can be done within an optimal time span. Furthermore, the researcher wishes to demonstrate that meaningful feedback can be given to students immediately after taking the test and that a comprehensive analysis of the results can be conducted within the normal classroom setting.

3.4.4 Acceptability Of The Delivery Medium

The researcher aims to show that the delivery medium, being computer based testing, is an acceptable medium to both students and tutors and thus does not contribute negatively to the performance of the students.

3.5 STUDY BOUNDARIES

3.5.1 Primary Spreadsheet Skills

It would not be prudent to embark upon the development of an all encompassing tool for the assessment of 'end user computing' knowledge *per se*. As pointed out in the literature study (Davis and Bostrom, 1993: 61), there is as yet no clear definition of the composition of such a curriculum. For this reason, the researcher

has confined this exploratory study to the assessment of **primary spreadsheet skills**. However, if shown to be an acceptable assessment tool within this context, further investigation as to its suitability to other aspects of end user computing can then be investigated.

3.5.2 Classroom Setting

With regard to the setting of the testing technique, the researcher has focused his attention upon the **classroom situation**. Therefore, the techniques and technology used will be those which are easily administered within the normal classroom situation by the end user educator who has an elementary grounding in mathematics or statistics. Although the need for a national standard and testing strategy was identified in the literature study (see paragraph 2.3), this study will confine itself to the classroom setting and function within the constraints of such a situation. It is the researcher's opinion that if the evaluation strategies suggested in this study are found to be successful at classroom level, a broader study can be conducted in order to assess the suitability of the technique to a wider and more formal arena such as a national certificate examination.

3.5.3 MS-DOS Operating System

The computer based testing software will be limited to run within the normal MS-DOS environment. The institution at which the research was conducted was not in a position to implement a MS Windows environment which would have enabled task swapping. This meant that the test was written by the students within a simulated spreadsheet environment.

3.6 SUMMARY

In order to address the need for a valid and reliable testing instrument which can be used for the assessment of end user computing learning outcomes, computer based testing will be used as the delivery medium for a criterion referenced test.

However, this research will limit its scope to the assessment of primary spreadsheet skills within the normal classroom context. The immediate objectives are to assess whether such an evaluation tool is:

- suitable to the knowledge domain being tested
- reliable and valid
- administratively efficient
- acceptable as a testing medium to both the students and the tutors concerned.

Should these objectives be satisfied, then recommendations can be given for it to be used as a prototype in the assessment of end user computing applications other than primary spreadsheet skills.

4. METHODOLOGY

4.1 INTRODUCTION

Cultivating a population of innovative end users is not the product of a single institution or examining authority. It is the responsibility of every end user educator to strive for this goal. Good end user education begins within the classroom.

The purpose of this chapter is to identify a methodology which can be used to develop a criterion-referenced evaluation instrument aimed at measuring the level of competence a student attains whilst attending a course on primary spreadsheet skills within the normal classroom setting.

4.2 SPREADSHEETS

The spreadsheet is one of the most widely used of all application software packages (Carland et al., 1988: 112). It is a very powerful tool which can be used in a number of different ways depending on the user. The two broad categories of application are to use it either as a decision support system tool or as a data processing tool (Awad, 1988: 307). In either context, "The most powerful use of spreadsheet software involves the ability to enter formulas as well as data so that the user may simulate various solutions to problems" (Schultheis, 1992: 138).

Although spreadsheets are easy to use, which is one reason for their popularity, it is essential that the user be aware of the underlying logic which is used in order to process data. There have been reports of users making blunders costing their companies millions of US dollars (Carland, 1988: 112). Many of these blunders arise as a result of failing to understand some of the fundamental principles of spreadsheet arithmetic and its underlying logic (Carland, 1988: 118).

4.2.1 Spreadsheet Misuse

In the figures shown below, a common misuse of spreadsheets has been illustrated.

	A	B	C
1	SALARIES		
2			
3	DATE:	10/11/93	
4			
5	HOURLY RATE	43.75	
6			
7	EMPLOYEES	HOURS WORKED	WAGES DUE
8			
9	SMITH J	24.5	1071.88
10	JONES R	13.0	568.75
11	ABLE K	17.0	743.75
12	NELSON T	28.0	1225.00

Figure 4.1 A SIMPLE WAGES WORKSHEET

Figure 4.1 shows a simple wages spreadsheet. At first sight nothing seems amiss. However, when the actual data entered into each cell are examined (see Figure 4.2), it is clear that the power of the spreadsheet has not been used at all. Instead of the cell references being used, raw values have been multiplied in order to determine the wage of each employee. If the hourly rate of pay increases, this will not be reflected in the final wage earned by each employee. While this error may seem trivial in this spreadsheet, it does occur in more complicated worksheets where data that fluctuates is used in its raw form within many cell calculations. When this value is changed, all cells using this value have to be edited and if any are missed, the result is an invalid spreadsheet. Furthermore, even if the user manages to maintain the validity of the worksheet in this manner, the inefficiency could result in the waste of many hours. Laudon (1988: 267) states that "The power of the electronic spreadsheet is that when you change a value or values, all other related values on the spreadsheet will be automatically recomputed." This power has been rendered ineffective in the current example.

	A	B	C
1	SALARIES		
2			
3	DATE:	10/11/93	
4			
5	HOURLY RATE	43.75	
6			
7	EMPLOYEES	HOURS WORKED	WAGES DUE
8			
9	SMITH J	24.5	43.75*24.5
10	JONES R	13.0	43.75*13
11	ABLE K	17.0	43.75*17
12	NELSON T	28.0	43.75*28

Figure 4.2 A SIMPLE WAGES WORKSHEET SHOWING THE CELL CONTENTS.

In the next example, illustrated in Figure 4.3 and Figure 4.4, a simple spreadsheet has been created in order to represent the accumulated costs incurred, in US dollars, when importing certain items. The final cost is then converted to Rand values using the exchange rate of the day.

	A	B	C	D	E	F
1	IMPORTS					
2						
3		US COST	WHARFAGE	CUSTOMS	TOTAL	RAND
4	RAND : DOLLAR			3.44		
5	VCR	389.85	3.51	148.143	541.50	1862.77
6	CD	188.45	1.70	71.611	261.76	918.41
7	NOTEPAD	1789.34	16.10	679.9492	2485.39	4215.35
8	MOUSE	38.26	0.34	14.5388	53.14	855.82

Figure 4.3 A SPREADSHEET WHERE COPYING HAS BEEN USED: CELL DISPLAYS ARE SHOWN.

While at first sight all may seem to be in order, closer scrutiny will cause doubt about the final Rand value of certain of the listed items when compared with the total dollar costs. If, however, the cell entries (shown in Figure 4.4) are examined, it can be clearly seen that the exchange rate has not been used in all of the conversions (column F of the spreadsheet). This is a common error made by users

when using the copy feature of spreadsheets. Fixed addressing should have been used in order to 'freeze' the cell containing the exchange rate. In large financial spreadsheets, errors like this can go unnoticed and result in decisions being made on the basis of invalid information.

	A	B	C	D	E	F
1	IMPORTS					
2						
3		US COST	WHARFAGE	CUSTOMS	TOTAL	RAND
4	RAND : DOLLAR		3.44			
5	VCR	389.85	0.009*B5	0.38*B5	+D5+C5+B5	+C4*E5
6	CD	188.45	0.009*B6	0.38*B6	+D6+C6+B6	+C5*E6
7	NOTEPAD	1789.34	0.009*B7	0.38*B7	+D7+C7+B7	+C6*E7
8	MOUSE	38.28	0.009*B8	0.38*B8	+D8+C8+B8	+C7*E8

Fixed addressing should have been used to reference this cell for the calculations in column F

Figure 4.4 A SPREADSHEET WHERE COPYING HAS BEEN USED: CELL CONTENTS ARE SHOWN.

There are many such examples of spreadsheet misuse as a result of the user not being aware of 'spreadsheet logic'. Incorrect series being used to create graphs is yet another such example. "To teach students and users of spreadsheets how to input labels, numbers and formulae into cells is a simple task. To go beyond those tasks and teach more advanced functions may be valuable, but effective education requires that users internalize one basic principle: users are responsible for output" (Carland, 1988: 118).

4.3 QUESTION MARK: A COMPUTER BASED TESTING SYSTEM

"Question Mark is a computer program to create, give, mark and analyse objective tests for IBM PC's and compatible computers" (Question Mark Computing, 1991: 1). The teacher is able to create a test which is delivered using a stand alone personal computer or a network for simultaneous delivery to multiple stations. The

system is flexible in that the subject matter to be tested is limited only to the creativity of the test author.

4.3.1 Overall Control And Student Feedback

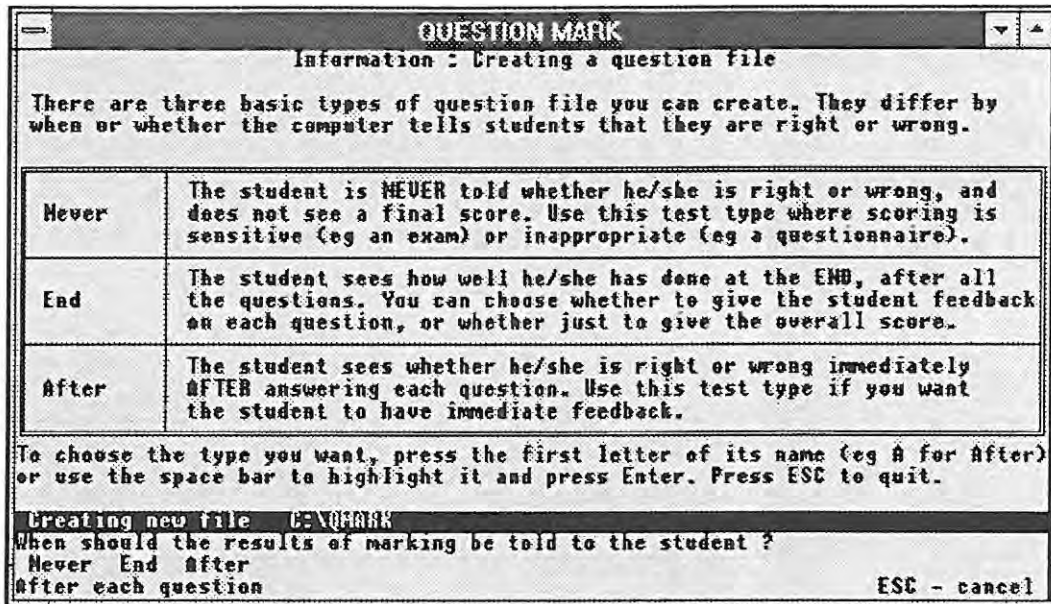


Figure 4.5 SETTING THE STYLE FOR STUDENT FEEDBACK. (QUESTION MARK VERSION 2.0: DIRECT SCREEN CAPTURE)

Control over the 'style' of test management is entirely in the hands of the teacher. Feedback to the student can be administered in three different ways (see Figure 4.5). The type of feedback chosen, being no feedback at all, feedback after each question or feedback only after the test has been completed, will be dependent upon the nature of the test being written.

Other features which can be set by the teacher (see Figure 4.6) include the following:

- a time limit may be set
- students may pass over questions which they cannot answer

- students may return to questions which were passed over and attempt them again
- students may alter their answers before a final assessment takes place
- questions may be presented to the student in linear order or at random from a given pool, or a mixture of linear and random questions.

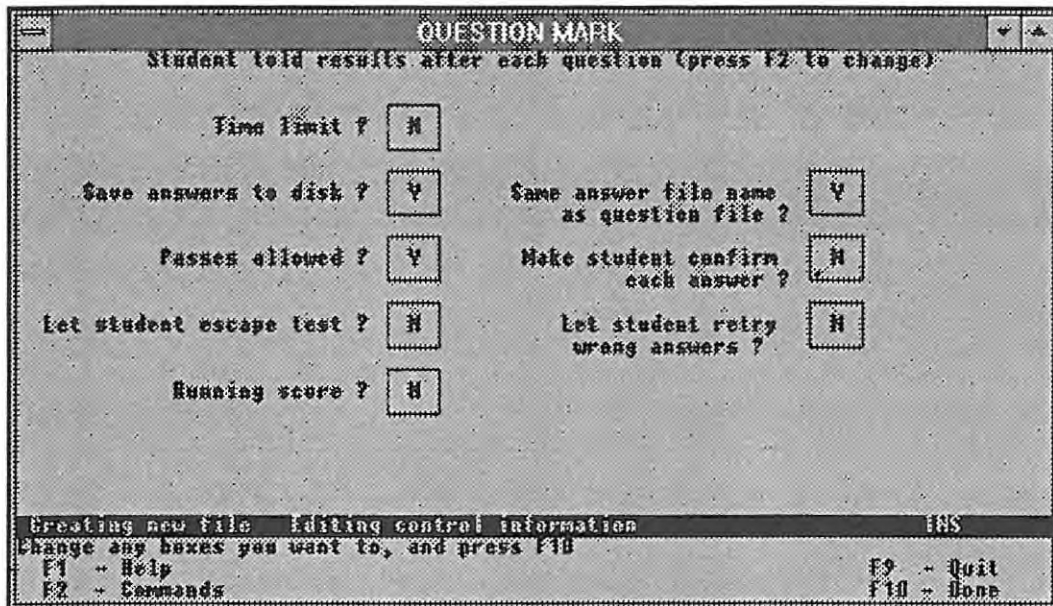


Figure 4.6 TEST CONTROL SCREEN (QUESTION MARK VERSION 2.0: DIRECT SCREEN CAPTURE)

A limitation of the version used for this study, which has been corrected in a subsequent version (version 3.0 and Question Mark for Windows), is that a difficulty level can not be attached to a question.

4.3.2 Question Style

Question Mark offers a wide selection of question formats from which to choose (see Figure 4.7). Examples of these can be found in APPENDIX C. The scoring of these questions can be controlled by the teacher so that a test can consist entirely of dichotomously scored items or credit can be given for partial knowledge. For instance, a question involving matching can be scored as correct or incorrect for

a perfectly completed task or marks can be assigned to the individual elements of the question. This includes negative marking for incorrect matching should the teacher wish to make use of this style of credit assignment. Partial knowledge can also be rewarded for issues such as incorrect spelling or, in the case of a numeric answer, an answer being supplied within a given proximity. The tolerance for spelling and numeric answer ranges is set by the teacher.

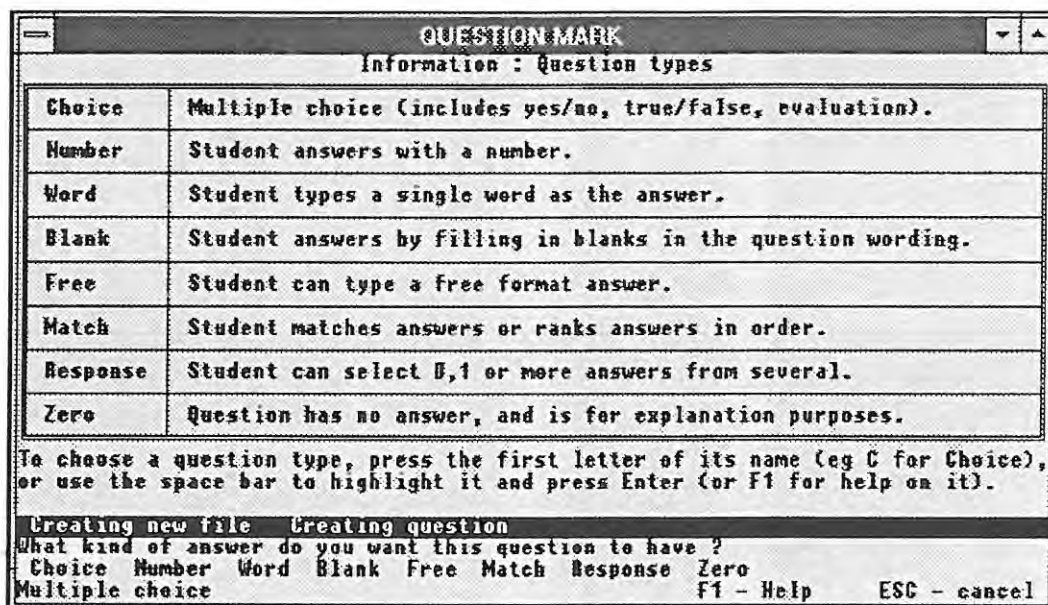


Figure 4.7 QUESTION STYLES AVAILABLE WITHIN QUESTION MARK. (QUESTION MARK VERSION 2.0: DIRECT SCREEN CAPTURE)

4.3.3 Student Score Management

Question Mark offers a comprehensive reporting system for the management of student scores (see Figure 4.8). The teacher can examine the scores of an individual student or an entire group. Summary reports can be obtained for a group or each student's performance on every question can be listed to either the printer or the screen or else written to an ASCII file. Furthermore, answer files can be converted to a spreadsheet format for further analysis. This was the method used in the current study for the analysis of the student responses to the test shown in APPENDIX L .

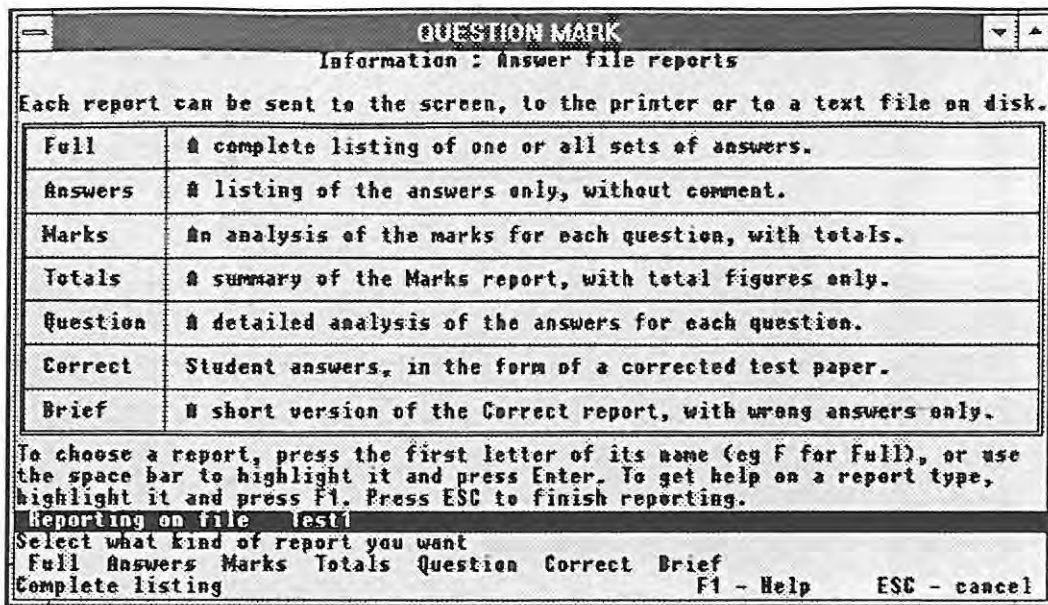


Figure 4.8 STUDENT SCORE REPORTS (QUESTION MARK VERSION 2.0: DIRECT SCREEN CAPTURE)

4.3.4 The Suitability Of Question Mark For Criterion-Referenced Tests

The construction of criterion-referenced tests will be discussed in paragraph 4.4. Many of the steps in the process, such as item analysis, reliability and validity testing as well as student feedback must be done within the briefest possible time span in order to be meaningful within the classroom context (Black, 1984: 26). Question Mark facilitates this adequately through its student score reporting facility and the tools which accompany this feature (see paragraph 4.3.3). Any remedial work can therefore be timeously commenced as a result of early analysis of the students' performance.

The students have immediate access to feedback on their test performance (see paragraph 4.3.1). This makes the test writing process far more relevant to the student. If a long waiting period between test administration and feedback is experienced, such feedback could be irrelevant to the progress of the student.

Some general criticisms of computer based testing which were raised by Plumly (1989: 74) include the following:

- students become frustrated at not being able to review previous questions
- students can not change answers to questions before committing their work for assessment
- only one question may be viewed at a time so that clues from other questions can not be used.

The first two points raised have been addressed in paragraph 4.3.1 where it was explained how the authors of Question Mark have overcome these difficulties. The third difficulty has been resolved artificially by students being enabled to page through a test, skip questions which they can not answer and return to them later. This will enable other questions to be scanned for 'hints' and this information used to answer a skipped question or alter an existing answer.

In the light of what has been said above, it would seem that Question Mark will serve as a suitable vehicle through which to administer a criterion-referenced test.

4.4 CRITERION-REFERENCED TEST DESIGN

Before adopting a design methodology, it is important to consider the following:

- the purpose of the test
- the environment in which the test is to be administered.

The boundaries of this study were established in paragraph 3.5 where it was stated that:

- **primary spreadsheet management skills** will be assessed
- the setting of the test will be within the normal **classroom situation**.

The design methodology used in the creation of the assessment instrument in this research has been one which satisfies the above study boundaries. This will be particularly important when specifying the domain definitions and conducting empirical analysis based on the students' test performances. Both Popham (1988: 288) and Black (1984: 53) stress that, within the normal teaching situation, the time available to the teacher does not permit lengthy administrative and design strategies.

Table 4.1 THE STEPS TO BE FOLLOWED IN THE CONSTRUCTION OF A CRITERION- REFERENCED TEST.

STEP	EXPLANATION
Domain Specifications	The learning objectives which are to be evaluated are specified in clear statements which serve as foundations upon which the test items are generated.
Item Construction	Items based upon the domain specifications are generated using appropriate formats being multiple choice, matching, ranking, etc.
Item Review	The items are assessed for content validity by judging their compatibility with the appropriate domain specifications. Empirical assessment of the items can be carried out as well after a pilot administration of the test has been conducted.
Standard Setting	A cut-off score is determined in order to classify the students as being 'masters' or 'non-masters' of the objectives being assessed.
Reliability	The test must be assessed in order to determine whether or not it is consistent in its measurement of the students.
Validity	The test must be examined to see that it in fact assesses what was intended. For this purpose, the following aspects of validity must be examined: content validity construct validity criterion related validity (predictive validity)

There is sufficient consensus within the literature [(Berk *in* Walberg, 1990: 491);(Hambleton *in* Walberg, 1990: 117);(Black, 1984);(Popham, 1988)] to consider each of the steps for the construction of criterion-referenced tests shown in Table 4.1 as being essential and, in principle, non-negotiable. Where movement can be allowed, as shown by Black (1984), is the degree of sophistication used in conducting each of these steps when creating a test. This will depend upon the environment in which the test will be constructed and administered. While the researcher wishes to stress that it is the responsibility of educators to be thorough and that they are accountable for their actions at all times, these efforts are constrained by their work conditions as well the skills they have at their disposal. The researcher has therefore examined the steps in Table 4.1 and attempted to identify strategies which will enable these stages of criterion-referenced test construction to be achieved with maximum effectiveness within the constraints of this study; classroom testing.

4.4.1 Domain And Instrument Specifications

Berk (*in* Walberg, 1990: 491) suggests that, among others, strategies such as the use of 'amplified objectives', 'item forms' or 'mapping sentences' should be used. However, Martuza (1977: 260) points out that the 'test situation' must be considered and that these strategies are time consuming and hence not generally practical within the classroom setting. Black and Dockrell (1984: 55) consider concise and explicit sentences which specify the objective being tested to be sufficient for the classroom setting. However, where a test measures more than one learning objective, each objective must be augmented by a domain specification upon which to base items that assess the students' mastery of that objective (Hambleton *in* Berk, 1984: 206 - 207).

In order to determine the mastery level (refer to paragraph 4.4.4) as well as make the domain specifications as functional as possible, the researcher will, at this stage of the test construction process specify the number of items to be set for each objective. This has been recommended by Priestly (1982: 54). As an

additional component, the score required for mastery of the objective will be set as well (Martuza, 1977: 246). Furthermore, the researcher will, for each objective, specify the proportion of items which will be allocated to a three level subset (Martuza, 1977: 188 - 191) of Bloom's taxonomy of cognitive skills, being:

- recall the student will be required to recognize or quote operational knowledge
- comprehension the student will be required to solve a problem which is stated "in such a way that the student is made aware of the information required to solve the problem"
- application the problem must be solved by the student without any resources being made available through the structuring of the question.

If each objective is clearly defined with its supporting domain specification and accompanied by the further specifications described in this paragraph, then the researcher will consider this as being an acceptable instrument specification (Black & Dockrell, 1984: 51 - 55) upon which to construct a test for classroom evaluation purposes.

4.4.2 Item Construction

Items are constructed in accordance with the domain specifications as described in paragraph 4.4.1. Therefore, the complexity of the approach will be a function of the format of the domain specifications [(Martuza, 1977: 255 - 267);(Roid in Berk, 1984: 49 - 77)]. In paragraph 4.4.1, the format of the domain and instrument specifications, which are within keeping of the standard set by Black and Dockrell (1984: 55) for classroom practice, were established. Therefore, it must be ensured that the items created for this study are in accordance with these specifications since the domain and instrument specifications determine the

construct validity of the resulting test. Furthermore, the traditional item construction rules must still be observed (Berk *in* Walberg, 1990: 490). Popham (1981: 237 - 241) established five major rules to adhere to, being:

- **clear directions** must be given to the student on how to answer the test
- **ambiguous statements** must be avoided at all costs
- **unintended clues** must not be given
- **complicated syntax** must be avoided
- **difficult vocabulary** must not be used.

A further consideration which must be taken into account is that of **bias** (Popham, 1981: 181 - 198). Social groupings can be identified in any society, particularly gender groupings. In multi-cultural societies, the groupings are numerous. Educators must ensure that their evaluation instruments are not biased so as to favour a subset of the student population being tested. In the classroom test situation, the teacher should be conscious of monotonic gender references; items which refer to members of only one racial group and socio-economic inferences which are of an exclusive nature. Although there are empirical procedures which can be applied to reducing test and item bias, such as item response theory (Mellenbergh, 1989), this is not within the scope of classroom practice. In their classroom practice, the teachers will have to rely on their own judgement (Popham, 1981: 184) with help from colleagues (Black, 1984: 67 - 77).

4.4.3 Item Review

Items are reviewed using judgemental and/or empirical procedures [(Black, 1984: 66 - 87);(Popham, 1981: 286);(Berk, 1984: 97)]. Judgemental review procedures are used to ascertain the "goodness of 'fit' and 'quality' of items" (Black, 1984:

67) with respect to the domain specifications. Empirical procedures analyse student responses obtained by 'piloting' such items with the aim of identifying the problematic ones (Popham, 1981: 287).

In the classroom situation, the researcher wishes to propose two easily administered tools, one of which is judgemental and the other empirical. The researcher points out that this would be the minimum that can be done in order to review items but within the normal teaching situation, time would not generally permit further investigation.

4.4.3.1 Judgemental Item Review

In order to assess the extent to which the items generated 'fit' the domain specifications, the "Item Content Review Form" (Hambleton *in* Berk, 1984: 224) should be completed by a selection or all of the teacher's colleagues. This form has been reproduced in APPENDIX E. The responses of the colleagues are collated and the mean calculated for each item. This value will then indicate which items are rated as being poor or good by the selected panel.

4.4.3.2 Empirical Item Review

A popular statistic used to assess the suitability of an item is that of 'Difficulty' shown in Equation 4.1 (Ashworth, 1982: 99). While the calculation of this index is certainly within the reach of the classroom practitioner, caution must be exercised in its use. The difficulty level of the item must be examined in the context of the question. In paragraph 4.4.1 it was pointed out that items should be generated according to a taxonomy of cognitive skills. Therefore, item difficulty must be examined within the context of the item's taxonomy grading. Furthermore, this statistic is based entirely upon the student population performance on that specific item. Neither the ability of the individual student nor the student's performance in the entire test is taken into consideration.

$$Difficulty = \frac{Number\ Wrong}{Number\ Attempting\ Question} \times 100$$

Equation 4.1 DIFFICULTY INDEX.

Latent Trait theory (Harris, 1986: 497) is a statistical process which is used in item analysis and addresses the issues raised above. "This latent trait statistic is based on the concept that an examinee with ability x will correctly respond to an item with given difficulty, discrimination and guessing parameters" (Harris, 1986: 497). Simply put, the greater the ability of the student, the greater the probability will be that this student will answer the item correctly. The processes used to determine the 'Item selection index' (Harris, 1986: 498) using Latent Trait theory are generally beyond the grasp of most classroom practitioners. However, Harris and Subkoviak (1986: 498 - 500) propose an approximation of this statistic which they demonstrate to be acceptable for classroom purposes. The calculation of the agreement statistic, $P(X_c)$, shown in Equation 4.2, is based upon the contingency grid in Table 4.2.

Table 4.2 CONTINGENCY GRID FOR COMPUTING $P(X_c)$

	master	nonmaster
correct	a_{11}	a_{12}
incorrect	a_{21}	a_{22}

a_{11} is the number of masters passing the item
 a_{12} is the number of nonmasters passing the item
 a_{21} is the number of masters failing the item
 a_{22} is the number of nonmasters failing the item

(refer to table Table 4.1)

$$P(X_c) = \frac{a_{11} + a_{22}}{N}$$

Equation 4.2 THE AGREEMENT STATISTIC.

Although the grid and statistic must be determined uniquely for each item, these are readily calculable by a classroom practitioner with access to a spreadsheet (see APPENDIX L).

When applying the agreement statistic to a set of data generated by administering a test to a group of students, the following boundaries should be used when interpreting the results:

- an ideal item has $P(X_c) = 1$ since all the masters will have 'passed' the item and all the non-masters 'failed' it so that $a_{11} + a_{22} = N$
- the practical lower bound of $P(X_c)$ is determined using Equation 4.3 which represents the proportion of classifications which can be expected by chance alone.

$$P(X_c) = \frac{(a_{11} + a_{12})(a_{11} + a_{21}) + (a_{21} + a_{22})(a_{12} + a_{22})}{N^2}$$

Equation 4.3 PRACTICAL LOWER BOUND FOR $P(X_c)$.

Since this statistic is dependent upon a **predetermined cut-off** score for the test as well as a set of student responses, the items must to be 'piloted' in order to gather this information.

4.4.4 Standard Setting

The setting of a standard by which students are classified as being masters or nonmasters of the work being assessed is rated by many researchers in the field as being the most complicated process in the construction of a criterion-referenced test [(Berk *in* Walberg, 1990: 492);(Shepard *in* Berk, 1984: 167)]. Sophisticated empirical methods can be used [(Huynh, 1982);(Huynh, 1985)] in order to determine a standard and make mastery/nonmastery decisions. However, human

judgement will always play a role in this process. Furthermore, complex procedures are time consuming and therefore not standard practice within the classroom (Berk, 1984: 189). For classroom purposes, it would seem to be appropriate to rely upon a judgemental approach towards setting a standard or cut-score (Black, 1984: 60 - 61) since "it is indefensible to spend more time on testing procedures than on teaching" (Berk, 1984: 189).

Selecting a single passing score for an entire test using a judgemental approach is not the most satisfactory methodology (Berk *in* Walberg, 1990: 493) since this could result in widely differing passing scores being set by different test administrators of the same test. In this study, the method used to set the cut-score for the test shall be that rated by Plake (1991) as being administratively easy yet sufficiently robust for the classroom situation. Minimum passing levels shall be set for each objective in the test produced in this study. The sum of these scores shall then be taken as the passing score (cut-off score) by which mastery/nonmastery decisions are made.

Before closing this section it must be pointed out that performance standards are continually subject to revision (Popham, 1981: 375). It must be remembered that in this study, the judgement decisions being made about mastery are not informed judgements since there is no well established existing evaluation strategy which can be used to assess end user knowledge (see 2.6). It must be accepted, therefore, that there will be a margin of error. The task of this research, as with any other in this field, is to minimize that error. In the next section, 4.4.5, it will be shown how the internal reliability coefficient can be used to generate a range of possible passing scores for a test. Decisions can then be made about this score which will be optimal from the point of view of consistency within the instrument.

4.4.5 Reliability

For the purposes of this study, reliability shall be interpreted as being the consistency with which masters and nonmasters classifications are made in terms

of the cut-off score which has been set for the test. For this purpose, the agreement coefficient p_0 has been recommended by Berk (1984: 261) for classroom use because of its ease of use. This statistic, which is a measure of the consistency with which students have been classified as masters or nonmasters, has traditionally been computed using two administrations of the test as shown in Table 4.3 and Equation 4.4.

Table 4.3 MASTERS/NONMASTERS CLASSIFICATIONS FOR TWO TEST ADMINISTRATIONS (BROWN, 1990: 82).

		ADMINISTRATION 2		
		MASTERS	NONMASTERS	
ADMINISTRATION 1	MASTERS	A	B	A + B
	NONMASTERS	C	D	C + D
		A + C	B + D	A + B + C + D

$$p_0 = \frac{A + D}{A + B + C + D}$$

Equation 4.4 AGREEMENT COEFFICIENT FOR TWO TEST ADMINISTRATION.

A two test administration may not always be possible within the normal classroom situation because of the temporal sensitivity of such a practice. However, Subkoviak (in Brown, 1990) has designed an estimation technique for approximating the agreement coefficient which requires only a single administration of the test.

The standardized cut-point score is calculated using Equation 4.5 where:

- z = standardized cut-point score
- c = raw cut-point score
- M = mean of the raw scores

S = standard deviation of the raw scores

$$z = \frac{(c - .5 - M)}{S}$$

Equation 4.5 STANDARDIZED CUT-POINT SCORE

The next step in the procedure is to calculate any one of the traditional norm referenced test internal reliability estimates. In this study the Kuder-Richardson formula 20 (see Equation 4.6) estimate will be used since the scoring of the items is dichotomous and the items are not all of equal difficulty by definition of the evaluation instrument (see 4.4.1). Note that from this point on throughout the text the Kuder-Richardson formula 20 will be represented by the abbreviation **KR20**.

$$KR20 = \frac{k}{k - 1} \left(1.00 - \frac{\sum var(i)}{Var(X)} \right)$$

Equation 4.6 KR20

where

k	=	<i>the number of items</i>
$var(i)$	=	<i>variance of a particular item distribution</i>
$\sum var(i)$	=	<i>sum of the item variances</i>
$Var(X)$	=	<i>variance of distribution of the test scores</i>

The agreement lookup table shown in APPENDIX M is then used as follows to determine the approximation for the agreement coefficient for a single administration of the test:

- the row with the closest value matching the absolute value of z is selected.
- the column headed by the value which is closest to the calculated value for KR20 is selected.

- the intersection point is then the approximation for the agreement coefficient.

Subkoviak (1988: 52) considers a value of 0.75 to be an acceptable lower bound for a normal class test.

A further approximation statistic which becomes readily accessible to the classroom teacher with very little extra effort is the **kappa** coefficient. The agreement coefficient has a calculated lower bound (shown in Equation 4.7) which is greater than or equal to 0.50. The kappa coefficient, shown in Equation 4.8, reflects the proportion of masters/nonmasters classifications observed beyond that expected by chance.

$$P_{\text{chance}} = \frac{[(a + b)(a + c) + (c + d)(b + d)]}{N^2}$$

Equation 4.7 THE LOWER BOUND OF THE AGREEMENT COEFFICIENT

$$K = \frac{(P_0 - P_{\text{chance}})}{(1 - P_{\text{chance}})}$$

Equation 4.8 KAPPA COEFFICIENT

The approximation procedure devised by Subkoviak (in Brown, 1990: 86) is exactly the same as for the agreement coefficient except that the **kappa** lookup table in APPENDIX M is used. For classroom practice, the kappa coefficient should not fall below 0.35 (Subkoviak, 1988: 53). It is normal for a classroom value to lie in the range 0.35 - 0.50.

The researcher would like to comment on a process suggested by Saltstone et al. (1988) where Subkoviak's estimation process has been computerised to produce a series of cut-off scores with the related values for the agreement coefficient and kappa being calculated (Saltstone, 1988: 252). This process has been replicated

using a spreadsheet (see APPENDIX L) with the added advantage that the restriction imposed by Saltstone (1988: 250), being that all items must be of equal difficulty, now falls away. The reason for this is that the researcher has recommended the use of the KR20 consistency estimation in place of the KR21 which Saltstone (1988: 250) used for the sake of computer processing economy. Within the classroom situation, a spreadsheet will easily manage the calculations required when using KR20 for group sizes compatible with normal classroom practice.

4.4.6 Validity

The purpose of validity studies is to determine if the measurement instrument does what it is supposed to do (Zeller *in* Walberg, 1990: 251). Even though a test may be acceptably reliable within the bounds laid out in paragraph 4.4.5, it will be reliably determining false masters/nonmasters classifications if it is not valid. Validity and reliability are therefore inter-dependent. There are three facets of validity which must be individually examined.

4.4.6.1 Content Validity

When assessing the content validity of a criterion-referenced test, the aim is to determine how well the test items reflect the domain specifications upon which they were constructed (Berk *in* Walberg, 1990: 494). In paragraph 4.4.3 a judgemental procedure for establishing the item congruence with the domain specifications was described. For classroom purposes, this procedure will satisfy Black and Dockrell's requirements (1984: 76 - 77) for assessing content validity of the instrument.

4.4.6.2 Construct Validity

Construct validity is rated by Popham (1981: 113) as being the most complicated of the three aspects of validity. The aim of construct validation is to assess

whether the test reflects a particular 'construct' to which some meaning is attached (Cronbach *in* Walberg, 1990: 255). Simply put, do the objectives which have been selected for evaluation and their domain specifications represent a sensible choice? Furthermore, is there some meaning in the way these objectives are related to one another.

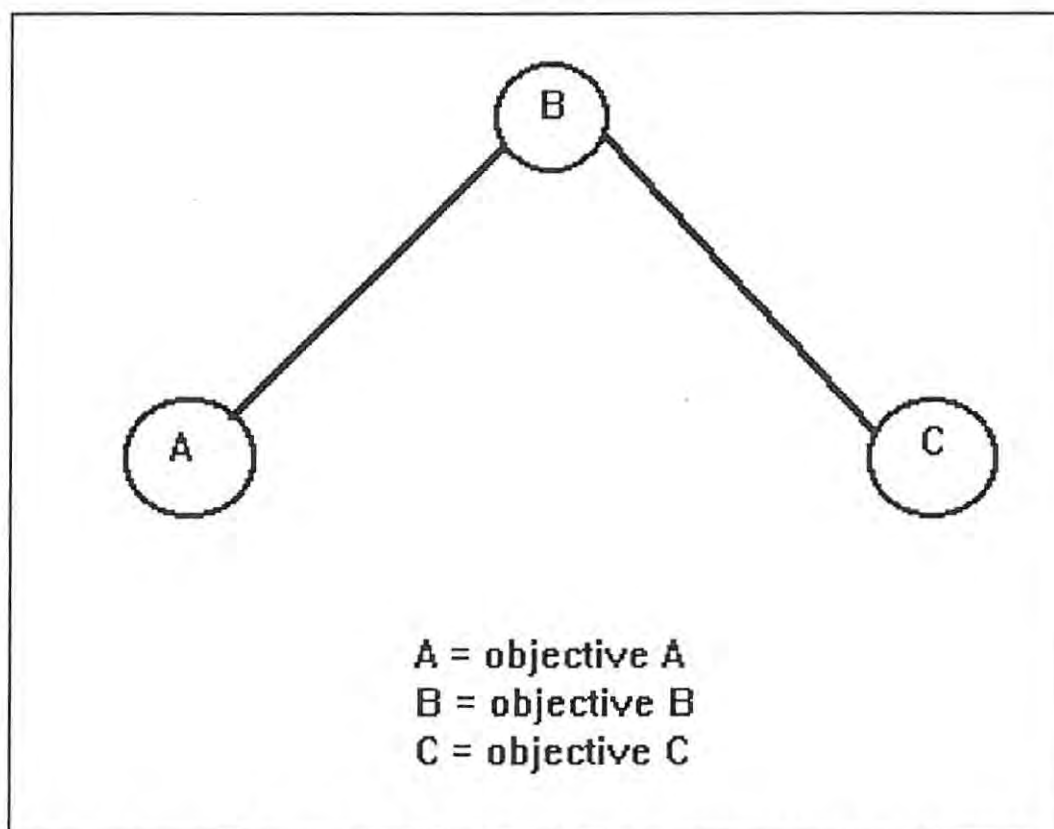


Figure 4.9 OBJECTIVE HIERARCHY FOR GUTTMAN SCALOGRAM ANALYSIS.

Factor analysis has been suggested as a means of thorough examination of the relationships between the objectives as revealed by the students' responses in order to quantify the construct reflected by the test (Zeller *in* Walberg, 1990: 255). This practice, however, is not within the bounds of classroom practice. Guttman scalogram analysis [(Berk, *in* Walberg, 1990: 494);(Berk, 1984: 216 - 217)], however, is a technique which can be readily used within the classroom situation.

In scalogram analysis, the objectives, as specified in the instrument description, are placed in a hierarchical order which is then used as a representation of the

cognitive construct the examiner expects to find revealed by the students through their responses. For example, a test having 3 objectives is created. The test designer establishes the hierarchical ordering of the objectives as shown in Figure 4.9. This diagram is then used to create a contingency table of possible mastery/nonmastery patterns which will reflect the 'construct' implied by the objective hierarchy. In this example, Table 4.4 reflects the construct intended by the test designer where "1" represents mastery on an objective and "0" nonmastery. The patterns shown in the table should be reflected by the majority of the students. Any 'frequent' occurrence of patterns other than those listed in the contingency table indicates problems in the assessment of these objectives or flaws in the hierarchical ordering of the objectives or both (Hambleton *in* Berk, 1984: 217).

Table 4.4 CONTINGENCY TABLE FOR GUTTMAN SCALOGRAM ANALYSIS

PATTERN NUMBER	OBJECTIVES		
	A	B	C
1	1	1	1
2	1	0	1
3	1	0	0
4	0	0	1
5	0	0	0

4.4.6.3 Criterion-Related Validity

In terms of this study, criterion related validity focuses upon whether mastery in the test is an indicator of proficiency in primary spreadsheet management or not. The evaluation tool in this study assesses the primary spreadsheet skills through objective questions based upon a given spreadsheet (see paragraph 5.2.2 and APPENDIX B). What is not assessed by this instrument is whether or not the students are able to construct a spreadsheet and use it for problem solving

themselves. This is the task which poses the problem since in order to assess this level of competence by means of evaluating the students' disks is expensive in terms of manpower (see paragraph 2.6). The criterion-related validity question in this study is, therefore:

to what extent can a student's score on the objective test be used as a predictor for performance on a test requiring the construction of a spreadsheet given the raw data?

The process which will be used in order to assess the relationship between the objective mastery test and the task of constructing a spreadsheet from raw data will be **cross-validation** (Martuza, 1977: 165). While item response theory certainly offers more rigorous empirical methods for criterion-related validation, these techniques fall outside of the scope of classroom practice.

For the purposes of this study, **cross-validation** will be implemented in the following way:

- the objective computer delivered test will be administered to the entire population
- immediately after completing the objective test, the entire population will complete a spreadsheet construction task from first principles
- the students' computer delivered test scores and task scores will be placed in a spreadsheet format
- students who do not submit an assignment or who do not submit original work should have their results excluded from the validation and reliability investigations
- the remaining sample will be split into two subsamples at random using the spreadsheet randomization function

- subsample A will be used to derive a prediction equation using linear regression where the score for the computer delivered test will be the independent variable
- the prediction equation will then be used to predict task scores for the students in subsample B
- the linear correlation between the predicted scores and the actual scores of subsample B will then be calculated
- this procedure will be completed 100 times in order to generate a bandwidth of correlation approximations rather than a single estimate.

4.5 THE POPULATION

Two populations were used in this study for two reasons:

- the statistical processes used are designed specifically to analyse the efficiency of a test after a single administration rather than using a test/retest approach.
- classroom practice does not generally permit a test/retest programme because of the constraints of curriculum and course scheduling.

The two populations are identical in all respects apart from the number of subjects. Both groups were second year Marketing students attending an end user computing course at the Port Elizabeth Technikon. The first population, being 98 in number, registered for this course in 1992 and the second population of 117 students attended the course in 1993. All the students in both populations were novice computer users and this was the first formal computer course they had attended.

The first population (1992) acted as the 'pilot group'. This group sat for the test in August of 1992 and their results were used for the initial item analysis and reliability review of the instrument. The refined test was then administered to the second population in July 1993. Their results were used to assess the initial reliability of the instrument as well.

The second population was required to complete the spreadsheet creation task as well in order to assess the validity of the instrument. This study was conducted within the bounds of normal classroom practice and was therefore subject to the anomalies of normal student behaviour. Of the 117 students, 12 did not submit a task at all and 8 students submitted collaborative work. In the case of collaborative work, the results of all the students concerned were discarded from the study. A sample of 97 students remained each of whom produced a test and project mark which could be used for empirical analysis.

4.6 SUMMARY

A criterion-referenced test will be designed according to a set of pre-determined instrument specifications which will contain the domain specifications upon which the test items will be based. The test will be administered to two population groups.

Once the test has been administered to the first population group, the agreement statistic will be used to perform an empirical analysis of the items. A judgemental review will be conducted as well. Items which do not perform satisfactorily will be improved or replaced with new questions. Subkoviak's method for determining the reliability indices after a single administration of the test will be applied to the test data in order to select an optimal cut-score which will then be used in the second administration of the test.

The second population will write the revised test as well as complete a spreadsheet project which will include the construction of a worksheet from first principles.

Students who do not submit original work will be excluded from the population. The results of the remaining sample will then be used for assessing the validity of the criterion-referenced test.

5. RESULTS

5.1 INTRODUCTION

The methodology described in the previous chapter will now be used to create a criterion-referenced test aimed at assessing primary spreadsheet skills within the normal classroom setting. The test, or evaluation instrument, will be created as rigorously as possible within the confines of the study and then assessed for reliability and validity. Validating the instrument, as will be shown in the following sections, is problematic within this study because of the lack of a pre-validated instrument to use as a comparative measure. A further difficulty within this study is that of the classroom setting. While the criterion-referenced test could be administered under controlled conditions, other procedures, assignments for example, could not. Therefore, the purpose of reliability and validation procedures will not be to propose the evaluation instrument as suitable or unsuitable for implementation but rather to justify or nullify the need for any further investigations of its suitability for use within and beyond the classroom setting.

5.2 CREATING A COMPUTER DELIVERED CRITERION-REFERENCED TEST AIMED AT ASSESSING END USER PRIMARY SPREADSHEET SKILLS

The methodology described in paragraphs 4.4.1 to 4.4.6.3 will now be used in order to construct and review a criterion-referenced test aimed at achieving the objectives as laid out in paragraph 3.4.

5.2.1 Domain And Instrument Specifications

The test delivery setting must be considered as a first step (see paragraph 3.4).

The Question Mark test delivery system will be used to administer the test under

normal classroom conditions with respect to the time allocated to the test. Although this is not a scientific approach to test length setting it is nevertheless a practitioner approach forced by circumstances. The time span allocated to the administration of the test is 1.5 hours which spans a normal laboratory teaching period. Unfortunately, the pre-conditions stipulated by Hambleton (1987: 342) were not able to be met in order to adopt an empirical approach for determining test length within this time span. These conditions include the pre-existence of a large, validated test bank of items. As these conditions could not be met in this study, a judgemental approach was used in order to determine the test length. Two minutes were allocated per item. Therefore, a test consisting of 45 items was decided upon.

5.2.1.1 Learning Objectives

The researcher identified six main learning objectives which the two populations were required to master when completing the spreadsheet module of their course. These were:

OBJECTIVE 1: SPREADSHEET OPERATIONAL PRINCIPLES

The student must display proficiency in the fundamental operational skills required to operate a spreadsheet.

OBJECTIVE 2: DATA ENTRY

The student must be able to enter, recognise and use data in its various spreadsheet formats.

OBJECTIVE 3: FORMATTING

The student must be able to apply formatting procedures to a spreadsheet in order to ensure that the correct numeric notations are used and that the

spreadsheet is easily interpreted.

OBJECTIVE 4: FUNCTIONS

The student must be able to use functions in the place of lengthy arithmetic statements.

OBJECTIVE 5: COPY

The student must be able to copy from specified source ranges to destination ranges and understand the relative range adaptations which occur in the process.

OBJECTIVE 6: WHAT IF

The student must be able to understand the cellular links which enable what-if analysis to be done.

5.2.1.2 Specifications

In paragraph 4.4.1, it was established that each learning objective must be augmented by a domain specification which clarifies the exact domain of learning/tasks which is to be assessed using the criterion-referenced test. The domain specifications for the instrument in this study can be found in APPENDIX A.

It was established in paragraph 4.4.1 that the instrument specification will include the inter-objective proportionate distribution of the test items as well as the intra-objective allocation of items to the three level cognitive taxonomy decided upon. This has been reflected in Table 5.1 where the mastery cut-scores for each objective have been entered as well. These cut-scores were decided upon according to the scheme described in paragraph 4.4.4. Dichotomous scoring will

be used for each item in the test in order to facilitate the reliability assessment procedures applied in this research.

Table 5.1 INSTRUMENT SPECIFICATION.

SPECIFICATION FOR LOTUS BEGINNER TEST 920821					
TOPIC	RECALL	COMPREHENSION	APPLICATION	TOTAL	MASTERY
Spreadsheet Principles	10	1	1	12	7
Data Entry	3	7	1	11	6
Formatting	0	4	4	8	4
Functions	2	3	2	7	4
Copying	0	3	1	4	2
What if	1	1	1	3	2
CUT OFF					25
%					56
Totals	16	19	10	45	
% composition	35.6	42.2	22.2	100.0	

5.2.2 Item Creation

The domain and instrument specifications created in paragraph 5.2.1.2 were used as the foundations upon which the items for the test were created.

In order to create items which were compatible with the domain specifications, a spreadsheet was created upon which to base these items. The spreadsheet is shown in APPENDIX B along with a graph based upon the spreadsheet also forming part of the template to which many of the test items refer.

Since a computer is the delivery medium for this test, the assessment of the students' responses is automated. This means that the researcher was not bound to a monotonic question style in order to facilitate easy tutor assessment of student responses. A wide spectrum of question styles was used; the choice being dependent on the individual question material. The resulting test is shown in APPENDIX C.

5.2.3 Item Review

The instrument created in paragraph 5.2.2 was administered to the first population group described in paragraph 4.5. The cut-score generated in the instrument specification, being 25, was used as the standard for determining mastery.

5.2.3.1 Empirical Review

Once the pilot population had completed the test using Question Mark, the answer file containing the students' assessed responses was converted to a spreadsheet format. The researcher used the product Quattro in order to perform further statistical processing. However, this is merely a consequence of personal preference since any proprietary spreadsheet will suffice in order to accomplish the task.

The results of the item analysis conducted by the researcher according to the strategy laid out in paragraph 4.4.3.2 can be seen in APPENDIX D. The three items which gave cause for concern, according to the agreement statistic, are 5, 11 and 25. All three of these items did not discriminate well between masters and nonmasters. Upon reflection, all three items erred on the side of being too easy in that unintentional clues were given. Replacements for these items which reflected the original intended domain specifications were written and these are shown in APPENDIX G.

5.2.3.2 Judgemental Review Of Items

The judgemental item review strategy used by the researcher was discussed in paragraph 4.4.3.1.

The instrument was reviewed by three of the researcher's colleagues who completed an evaluation form which is shown in APPENDIX E. The calculated means of the item/domain congruence scores given by the assessors for each item

are shown in the table in APPENDIX F. After consultation with the assessors, the researcher decided that a mean item/objective congruence score of less than 4 (see APPENDIX F) was not acceptable. As a result of this condition, items 15, 21 and 22 were replaced with alternate questions which were then approved by the assessors as being more suited to assessing the objectives in question, being formatting of data entries and column characteristics. These three replacement items are shown in APPENDIX G.

The researcher wishes to stress that items which were regarded as being below standard as a result of the empirical test were rated as being acceptable using judgemental procedures. The inverse of this was true as well. It is therefore essential, even in classroom practice, that both empirical and judgemental methods be used in a complementary manner.

5.2.4 Setting The Cut-Score And Reliability Checking

The cut-score, or standard, was determined while creating the instrument specifications (see Table 5.1). The methodology used in this process was discussed in paragraph 4.4.4 where it was pointed out that the cut-score is not a static characteristic of the test to be treated in isolation. Reliability checking and standard setting are interwoven processes. The results of the internal reliability/consistency indices investigation using Subkoviak's reliability checking technique, which was explained in paragraph 4.4.5, are shown below:

<i>MEAN OF RAW SCORES</i>	=	<i>25.90</i>
<i>KR20</i>	=	<i>0.82</i>
<i>Cut-score</i>	=	<i>25.00</i>
<i>Z</i>	=	<i>0.22</i>
<i>AGREEMENT COEFFICIENT (APPROX)</i>	=	<i>0.80</i>
<i>KAPPA COEFFICIENT (APPROX)</i>	=	<i>0.59</i>

The value obtained for the agreement coefficient approximation, being 0.80, is above the lower bound of 0.75 set by Subkoviak (1988: 52) for classroom

practice. This means that the consistency with which the evaluation instrument classifies students as being masters or nonmasters with respect to the cut-score of 25 (established in the instrument specification) is well within the bounds of acceptance. The approximation for the kappa coefficient, 0.59, is above the bandwidth suggested for classroom practice. The calculated value for KR20, 0.82, is above that which is minimally tolerable for classroom practice as well, being 0.70. In view of the above, it would seem that the consistency with which the instrument classifies students as being masters or nonmasters beyond that expected by chance is acceptable for the purposes of this research. However, the question which must be asked is the following:

is the cut-score used in this pilot administration of the test acceptable for future administrations?

A naive answer would be 'yes'. However, an important part of test design is to consider the environment in which the test is to be administered (see paragraph 4.4.1). If this environment should change then the test characteristics must be reviewed. The population group which sat for the piloting of the test was completely new to the Question Mark environment. The second population to sit for this test were familiar with Question Mark. There was a greater confidence in the test delivery medium.

An added factor which caused the researcher to question the possibility of a 'static' cut-score was that of tradition. Even though four people were influential in the setting of a mastery level for each objective and these judgements were used to arrive arithmetically at the cut-score, the traditional pass requirement of 50% (being the minimum passing level for Technikon courses) seemed to play a part. For this reason, approximations of the reliability indices were calculated for a range of cut-scores. The methodology for this is described in paragraph 4.4.5 and APPENDIX L. The results of this analysis are shown in Table 5.2.

Table 5.2 OPTIMIZATION SCANNING FOR CONSISTENCY INDICES

OPTIMIZATION SCAN FOR RELIABILITY INDICES								
CUT-SCORE	23	24	25	26	27	28	29	30
Z	0.54	0.38	0.22	0.06	0.10	0.26	0.41	0.57
AGREEMENT	0.82	0.81	0.80	0.80	0.80	0.80	0.81	0.83
KAPPA	0.58	0.58	0.59	0.59	0.59	0.59	0.58	0.57

The kappa coefficient is an indication of the consistency of masters/nonmasters classifications above that which can be expected by chance. Table 5.2 shows that the greatest consistency can be expected within the cut-score range 25 - 28. This band includes the cut-score established for the pilot administration of the test meaning that optimal internal consistency has been achieved by using this value. However, in the light of what was said about the second population being more familiar with the testing system, it was decided to use the upper bound of this band as the cut-score when administering the test a second time. A further factor mitigating in favour of this decision was an agreement amongst the researcher's colleagues that 56% (25/45) was not an acceptable indication of 'mastery' of primary spreadsheet principles. In order to achieve the greater goal established in paragraph 2.4.1 on page 8 being, to foster innovative end users, greater proficiency in fundamental tasks must be shown by the prospective end user than is indicated by a mark of 56%.

The test was administered to the second population of students in July 1993. The performances of the students within the remaining sample after the exclusions described in paragraph 4.5 had been made were used to produce an internal consistency scan for a range of cut-scores. The scan is shown in Table 5.3.

Table 5.3 OPTIMAL INTERNAL CONSISTENCY INDICES, SECOND TEST ADMINISTRATION

OPTIMIZATION SCAN FOR INTERNAL CONSISTENCY INDICES									
CUT-SCORE	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00
Z	0.92	0.75	0.58	0.40	0.23	0.05	0.12	0.30	0.47
AGREEMENT	0.87	0.85	0.83	0.81	0.80	0.80	0.80	0.80	0.82
KAPPA	0.55	0.56	0.57	0.58	0.59	0.59	0.59	0.59	0.58

Table 5.3 shows that the original choice of 28 as the cut-score falls without the range of cut-scores offering the best internal consistency above that achieved by chance (kappa coefficient). The minimum cut-score would be 31 in order to obtain the maximum consistency. According to Saltstone et al. (1989: 252), it is quite acceptable to establish a cut-score for mastery after the test has been written.

The above discussion of internal consistency of the instrument has been centred about the cut-score and its effect upon the consistency of classifying masters and nonmasters. The value obtained for KR20 (on the second administration of the test) was 0.82. This value, as an index of overall dependability of the scores without reference to the cut-score, is well above that recommended by Subkoviak (1988: 52) as being the minimum acceptable value which is 0.70.

It is not the researcher's intention to reopen the discussion on item review at this stage since this is a never ending process when building test banks. However, it is of interest to note that when using a cut-off score of 31, an empirical review of the items shows that each item performs satisfactorily in the administration of this test (see APPENDIX H).

5.2.5 Validity

Content validity has already been addressed in this study (see paragraphs 4.4.6.1 and 5.2.3.2).

5.2.5.1 Construct Validity

In paragraph 4.4.6.2 it was established that this study will limit itself to a Guttman scalogram analysis. The researcher recommends caution in the use of this technique. The establishing of a hierarchical ordering of the objectives in the test constructed in this study was done purely on the basis of experience on his own part and those of his immediate colleagues who assisted in the ordering. Therefore the construct validity analysis conducted in this study is founded upon judgemental procedures applied to the classroom situation.

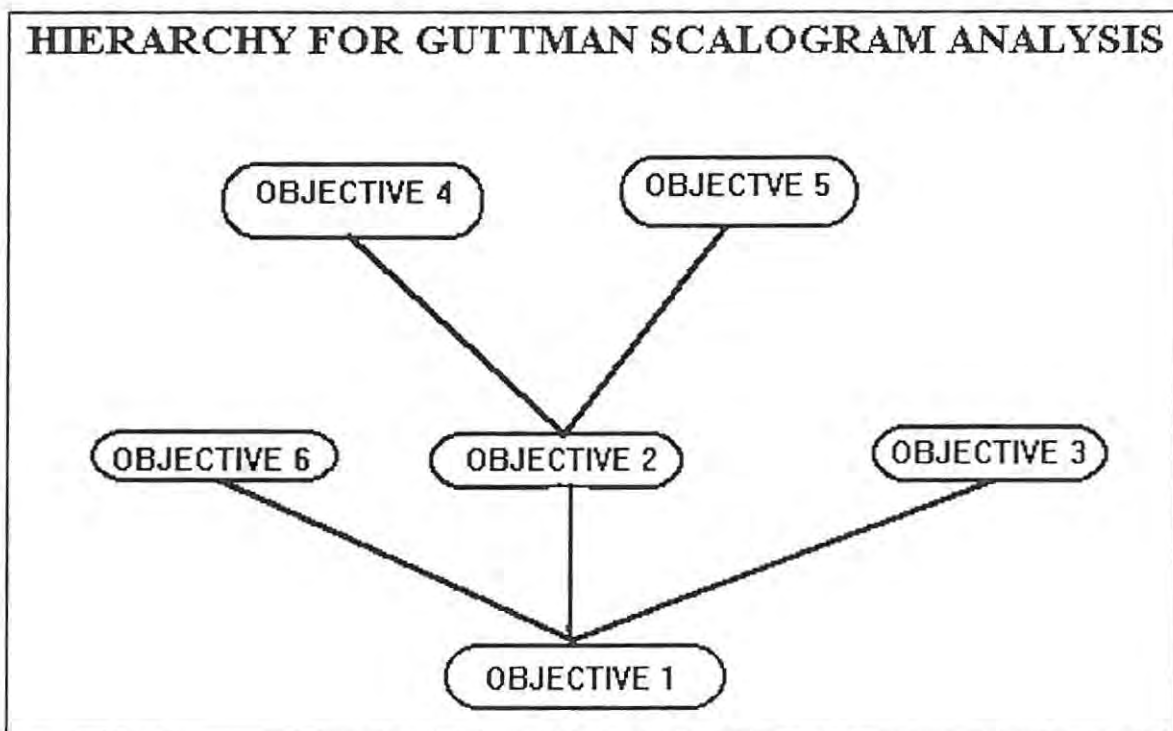


Figure 5.1 HIERARCHY OF OBJECTIVES FOR GUTTMAN SCALOGRAM ANALYSIS.

The researcher considers the hierarchical ordering of the six objectives being examined by this instrument to be that shown in Figure 5.1. The motivation for this ordering is that "spreadsheet operational principles", being objective 1, is the foundation for all the remaining five identified objectives. However, the successful use of functions, being what objective 4 sets out to measure, and copying (objective 5) are dependent upon the student having a good understanding of the

principles of data entry for spreadsheets (objective 2).

The contingency table for this hierarchy is shown in Table 5.4 where the counts for each pattern have been given as well. The total number of students who have mastery patterns conforming to one of those in the contingency table is 58 which constitutes 60% of the sample. This would seem to indicate that there is evidence to suggest that the construct as described in Figure 5.1 is consistent with the pattern of the majority of student responses.

Table 5.4 CONTINGENCY TABLE WITH STUDENT COUNTS

PATTERN NUMBER	COUNT	OBJECTIVES					
		1	2	3	4	5	6
1	5	1	1	1	1	1	1
2	0	1	1	0	1	1	1
3	0	1	1	0	1	1	0
4	0	1	1	1	1	1	0
5	25	1	1	1	1	0	1
6	8	1	1	0	1	0	1
7	2	1	1	0	1	0	0
8	12	1	1	1	1	0	0
9	0	1	1	1	0	1	0
10	0	1	1	0	0	1	0
11	0	1	1	0	0	1	1
12	0	1	1	1	0	0	1
13	1	1	1	0	0	0	1
14	1	1	1	0	0	0	0
15	0	1	1	1	0	0	0
16	0	1	0	1	0	0	1
17	1	1	0	0	0	0	1
18	1	1	0	0	0	0	0
19	0	1	0	1	0	0	0
20	2	0	0	0	0	0	0
TOTAL	58						

The researcher would like to stress once again (see paragraph 4.4.6.2) that caution must be exercised in interpreting this result. All that has been revealed is some evidence to support the relationship, as perceived by the researcher, between the objectives. That this evidence comes from the administration of the test to the population means that the instrument reflects the 'construct' the researcher intended it to. More rigorous research must be conducted in order to describe

scientifically the construct which is measured by the test if it is to be used beyond the bounds of normal classroom practice.

5.2.6 Criterion Related Validity

In paragraphs 4.4.6.3 and 4.5 a description was given of the process to be used in assessing the predictive validity of the instrument. Before discussing the results of applying the strategy, it is important to review some of the limitations of this study.

This study has been conducted under normal classroom circumstances. Therefore, any time used in order to administer tests was that which can be afforded under normal classroom circumstances. This posed no problem in the administration of the computer delivered criterion-referenced test. However, the project which the second population group had to complete could not be administered within the normal time period allocated to a classroom period. For this reason, the project was set as a homework task.

Two of the hazards of normal class conditions and homework tasks are:

- work which is not submitted
- submission of work which is not original.

Therefore, since 8 students did not submit a completed task and a further 12 submitted matching efforts, the remaining sample for the purposes of the study was 97 in number. It may be that within this number there were further members who did not submit work which was entirely their own effort. This could cause a distortion of the validation process.

A further consideration is that the project which is used as the criterion measure is itself not a validated instrument (see paragraph 2.6). Therefore, at best this

study can only produce evidence that a computer delivered criterion-referenced test can be used as a measure of primary spreadsheet management (including construction) or not. The task which was used as the criterion measure is shown in APPENDIX J. The assessment of the projects was done according to the scheme shown in APPENDIX K. The tasks submitted by the student were assessed by the researcher alone therefore any discussion of inter-rater consistency is not meaningful here. However, as marks were allocated to individual identified tasks (as shown in the marking scheme), it was possible to determine the intra-rater consistency using KR20 as an index. A value of 0.79 was obtained making the consistency sufficiently comparable to that of the computer based test which had a KR20 value of 0.82. No effort was made to consider a cut-score for this project since it is itself not a rigorously validated instrument and all we are looking for is sufficient evidence of a positive relationship between the students' achievements on the computer delivered test and their performances on the project.

5.2.6.1 Cross-Validation

The researcher was not satisfied by making a single arbitrary random split of the sample in order to determine the prediction equation, based upon one half of the split, and subsequent linear correlation between the predicted and actual scored task values achieved by the remaining half. For this reason, one hundred such splits and resulting calculations were made. This task is made simple through the use of spreadsheet macros. The Pearson correlation coefficient values ranged from 0.68 to 0.83; in other words from moderate to strong. The 100 correlation values were rounded to two significant figures and then placed in stepped intervals of 0.03 units as shown in Table 5.5.

The mode for the 100 calculations of the Pearson correlation coefficient was located in the 0.745 - 0.775 interval and the median in the 0.775 - 0.805 interval. While this can only be termed a **reasonably reliable** set of values for this index (Ashworth, 1982: 109), the researcher would like to stress once again the 'uncontrolled' circumstances under which the 'project' test had to be administered.

Table 5.5 FREQUENCY DISTRIBUTION OF PEARSON CORRELATION COEFFICIENT VALUES FOR 100 CALCULATIONS.

PEARSON BANDS	FREQUENCY
0.655-0.685	0
0.685-0.715	6
0.715-0.745	11
0.745-0.775	29
0.775-0.805	20
0.805-0.835	26
0.835-0.865	8
0.865-0.895	0
N	100

Notice must be taken of the fact that a correlation coefficient above 0.80 was obtained a sufficient number of times, 34% of the readings (see Table 5.5), to mitigate in favour of a good positive relationship possibly being found to exist between the two scores. A reading of between 0.80 and 0.90 should be expected in order to demonstrate conclusively a strong positive relationship between the scores (Popham, 1981: 89).

Finally, in Figure 5.2, the researcher has shown a scatterplot where the students' achievements in the 'project' have been plotted against their achievements in the computer managed test. It is the researcher's opinion that this plot reveals a reasonable linear tendency which is sufficient to infer satisfactory classroom practice criterion validity (Ashworth, 1982: 108 - 109) considering the uncontrolled circumstances of the administration of the 'project' and the possible distortion as a result of this.

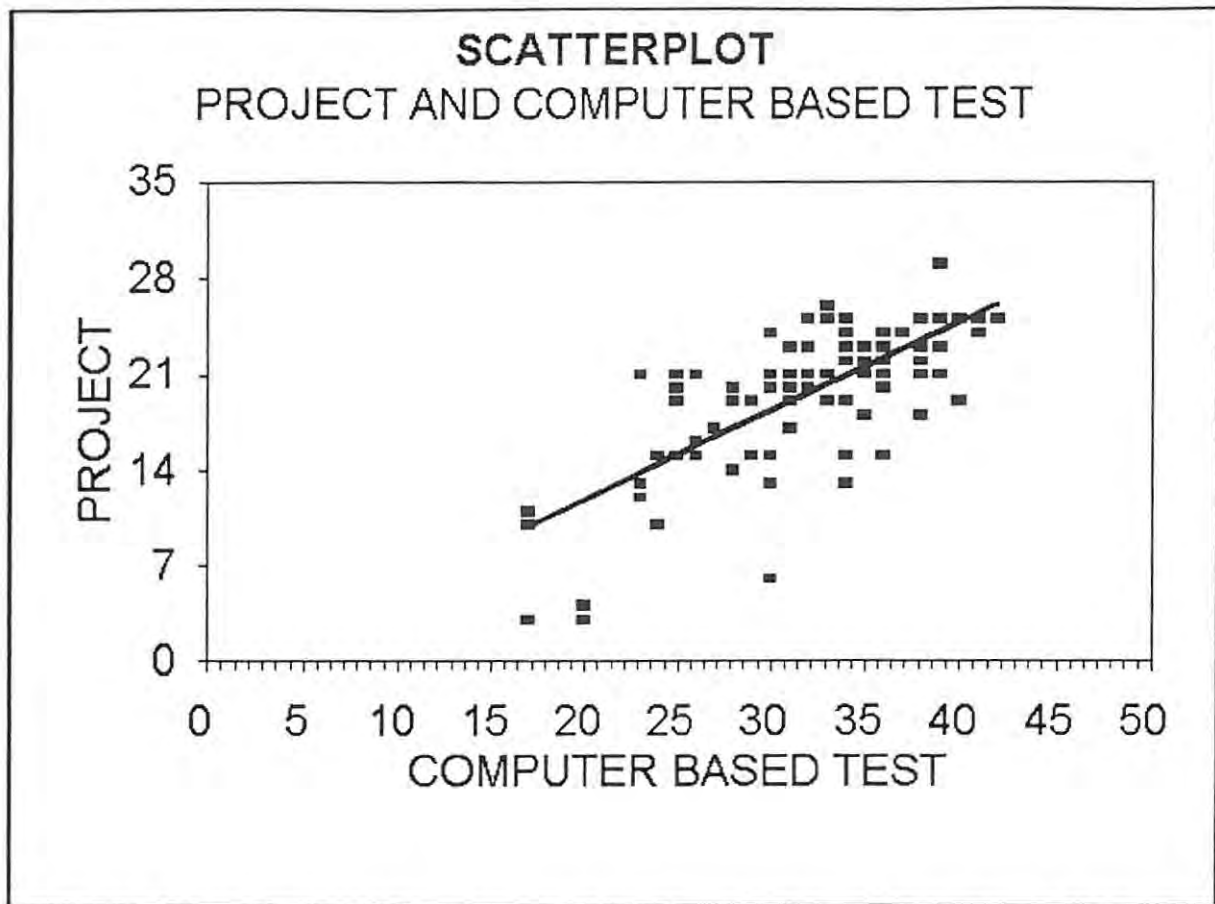


Figure 5.2 SCATTERPLOT OF PROJECT SCORE AGAINST COMPUTER MANAGED TEST SCORE FOR THE ENTIRE SAMPLE.

5.2.7 Efficiency Of The Instrument

One of the goals of this study was to identify an evaluation technique which is efficient in terms of administration (see paragraph 3.4.3).

Creating the test using Question Mark was a lengthy process. Two working days of eight hours each were spent on this task while only a morning was spent in preparing the problem sketch for the project. However, the assessment of the students' responses in the computer delivered test was instantaneous. The assessment of 109 students by scrutinizing their disks took in excess of three full working days. Furthermore, the responses of the students in the computer administered test were quickly translated to a spreadsheet format and analysis of the data (see APPENDIX L) could begin immediately. In the case of the projects,

the scoring awarded to the students on each task had to be entered on to a spreadsheet manually before any further analysis could take place.

5.2.8 Acceptability Of The Delivery Medium

Rigorous studies have been conducted in order to gather attitudinal trends amongst students using computer based testing [(Plumly et al., 1989); (Bernt et al., 1990); (Palumbo, 1989)]. To emulate such studies which rely heavily on factor analysis in this research is not feasible considering the bounds of classroom practice. Data gathering for survey purposes is not a problem within the classroom situation. However, the collation and processing of that data is very time consuming and not a normal practice in the 'real' classroom situation. But surveys can be conducted using a computer based testing system and the data quickly translated to a readily manipulable format.

The researcher conducted a 'naive' survey within the second population in order to gather grass roots attitudes towards this mode of testing. This survey was 'tagged' on to the end of the spreadsheet test so that the students completed it immediately after sitting for the computer administered spreadsheet test. This survey is shown in APPENDIX I in text format. A score of 1 - 5 was allocated to each item within the survey where 1 represents a very negative attitude and 5 a very positive one. The students' responses were converted to a spreadsheet format and used to construct the graph shown in Figure 5.3.

The only item to be given a mean rating of less than three by the entire population was item 1. The question posed in this item was

"Were you nervous about taking this test?"

In the light of the question, the researcher is satisfied that in general the students are positive about this mode of testing within the setting in which this study was conducted.

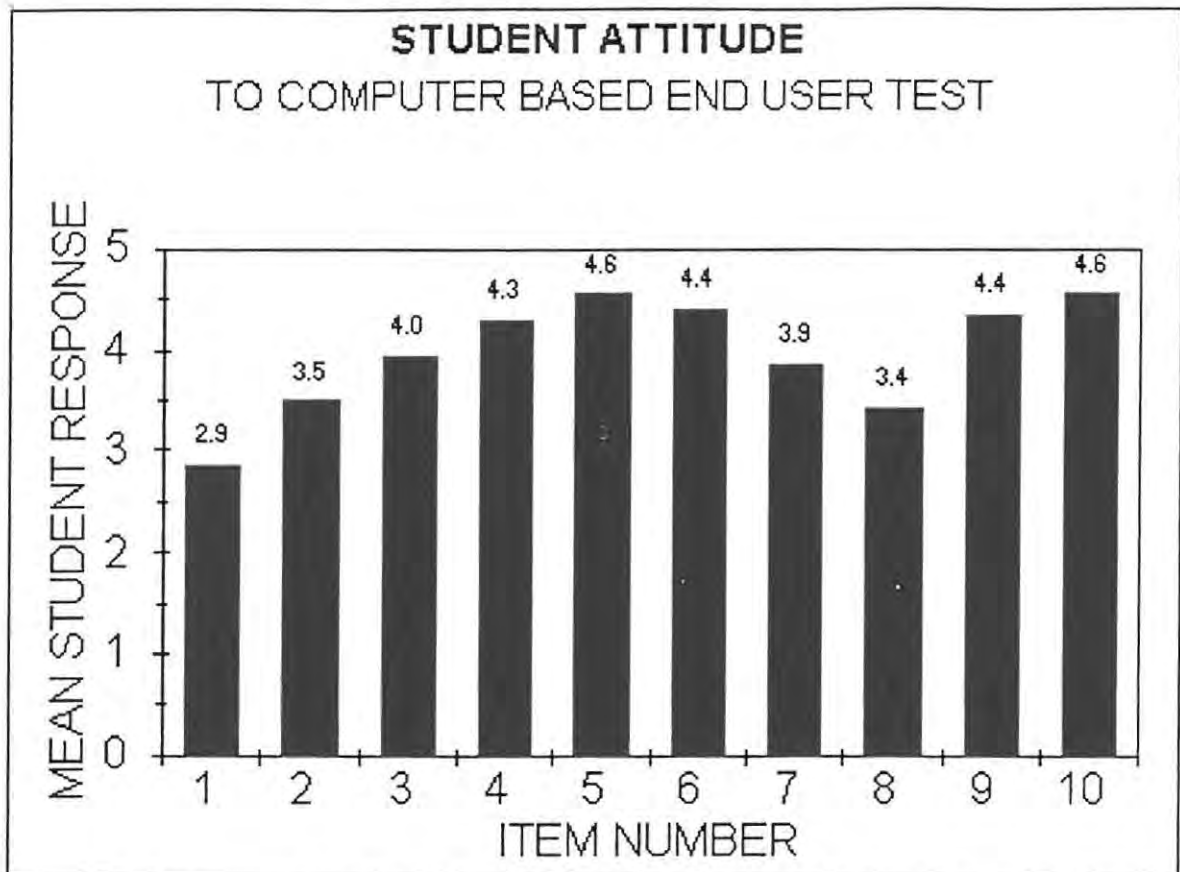


Figure 5.3 THE MEAN RESPONSES OF THE SECOND POPULATION TO THE ATTITUDINAL SURVEY.

5.3 SUMMARY

The assessment of students' tasks by means of examining their disks is a time consuming process which erodes valuable teaching time. However, assessment of students is necessary in order to implement remedial contingency plans as well as to gauge whether or not the objectives of the course have been mastered.

In the preceding paragraphs it has been shown that a computer mediated evaluation instrument can be created which is, for the purposes of classroom practice,

- efficient in terms of student response assessment and collation of students' results for further analysis

- acceptable to students as a stimulating and fair mode of evaluation, providing timeous and personalized feedback
- internally consistent with respect to mastery and nonmastery classifications.

With regard to the validation of the instrument, the difficulties experienced were

- the lack of a pre-validated alternative instrument to use as a criterion measure
- the lack of existing studies in the 'cognitive construct' which a master of spreadsheet management may exhibit
- that the procedures used to obtain evidence of the predictive value of the computer based test were subject to an uncontrolled procedure.

In view of the above difficulties, encouraging evidence was found to support the existence of a reasonable relationship between the students' performance on the computer based test and their achievement in a grass roots spreadsheet construction assignment. Furthermore, a conservative majority of students exhibited a 'construct' in their mastery/nonmastery of the objectives in the test which was compatible with the hierarchical ordering of the objectives perceived by the researcher.

It would seem therefore, that sufficient evidence has been gathered using judgemental and uncontrolled procedures to warrant the instrument being subjected to a further more rigorous investigation with regard to its suitability for end user computing student evaluation beyond the normal classroom setting.

6 CONCLUSION AND RECOMMENDATIONS

An end user of information technology has been shown to be a valuable asset to any country (see paragraph 2.3). However, in order to utilize information technology to its maximum, the end users must develop beyond the stage of data entry and retrieval. Innovative use of computers is the goal of effective end user education. An important component of any educational strategy is student evaluation in order to assess whether or not mastery of the learning material has occurred.

In information technology end user education, the assessment of students has been found to be problematic in that it is very time consuming. It was shown that in some instances end user educators avoid the issue of evaluation and award qualifications on the basis of course attendance (see paragraph 2.6).

In this study, primary spreadsheet skills were identified as being a suitable topic to focus on for the purposes of designing an evaluation instrument which, within the normal classroom setting:

- is criterion-referenced
- is easily administered from the point of view of assessing the students' responses and collating the data for further analysis
- displays an acceptable level of consistency with respect to the classification of masters and non-masters
- is valid.

The instrument developed proved to be reliable and an acceptable means of evaluation from the students' point of view. Furthermore, the collation and analysis of the students' responses was made extremely simple by using the Question Mark

computer based testing system as the delivery medium.

The chief limitation of this study proved to be that of the normal classroom situation where time is at a premium and the fact that the researcher could not identify an existing, validated evaluation tool against which the performance of the instrument could be measured. For this reason, the validation techniques used were

- judgemental in the case of construct validity checking
- subject to the use of an uncontrolled procedure in order to gather evidence of predictive validity.

The researcher is satisfied that sufficient evidence was revealed by this uncontrolled situation to warrant a more rigorous and controlled investigation of the suitability of this evaluation technique within the field of end user computing. Specific issues which warrant research are listed below.

A detailed analysis of the underlying 'cognitive construct' which is manifested by the innovative user of spreadsheets is required. This will enable an informed construct validation of assessment instruments to be conducted.

In order to make a rigorous assessment of whether or not a computer managed criterion-referenced test can be used as a prediction for spreadsheet management from first principles, a controlled study must be made at least at classroom level. This implies the administration of the computer based test under controlled circumstances as well as the administration of the assignment. However, the assignment itself must be subjected to rigorous analysis if reliability and validity are to be assessed. Of special importance here will be the mastery/nonmastery classification of the instrument. No mention was made in the current study of false mastery/nonmastery classification. This is most certainly an issue needing further research.

The current study has focused only upon spreadsheets. What of the other aspects of end user computing such as Word Processing and Database to name just two? The important thing to remember in using the computer managed learning style of test delivery is that the student is not being asked to perform a specific task but rather how a task should be carried out. The researcher has created tests for assessing Word Processing and Database skills which have performed equally as well as the current study in spreadsheet management has. Therefore, rigorous assessment of the technique is required in order to determine the suitability of the instrument to the broader aspects of end user computer skills assessment. In this regard, the same difficulties of validation exist for these other topics as found when attempting to validate the spreadsheet test.

The test created in this study was static in the sense that the questions were either of a general nature or centred around a paper printout of a worksheet. This is a limitation of the MS-DOS operating system where only one application can be run at any time. If this mode of testing could be conducted using a dynamic spreadsheet so that the student must perform actual spreadsheet management tasks in order to answer the items, the scope of application would broaden remarkably. Using a computer based evaluation system which runs in the Windows environment would overcome this difficulty since the student could then toggle between a live spreadsheet (word processing or database) application and the testing system in order to complete a test. Question Mark released a Windows version of their product in September of 1993. The researcher would urge that any future investigations of this technique of end user evaluation focus upon the Windows environment.

The above research recommendations are not limited to classroom practitioner level. The current study was bound by this limitation. If the above recommendations are pursued further then it would be of value to adopt rigorous contemporary methods of empirical analysis such as item response theory. This implies the accumulation of large item banks and sample groups which would seem

to point towards a national study. In view of the remarks in paragraph 2.3 concerning the strategic value of innovative end users to any nation, it would seem reasonable, in the light of the promise shown by this instrument within the uncontrolled classroom situation, to investigate rigorously its application at national level.

At classroom practitioner level, the researcher considers this instrument to be sufficiently robust to be used for routine classroom testing. The computer based testing instrument offers the teacher an excellent opportunity to easily analyse the responses of students in order to assess the areas in which remedial tuition is required. Furthermore, the data gathered in this way can be used, with the aid of a spreadsheet to easily and quickly analyse the students' responses in order to assess the quality of the test. This is normally not done within the classroom situation because of the time it takes to do this by hand. However, until such time as the instrument has been rigorously validated, it would be unwise to use it in situations beyond that of the normal classroom such as an examination for a national qualification. This does not, however, exclude use being made of it within such a course for regular classroom testing so long as supporting measures are used in the assessment of the student for certification purposes.

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APPENDIX A: OBJECTIVES AND DOMAIN SPECIFICATIONS

OBJECTIVE 1: SPREADSHEET OPERATIONAL PRINCIPLES

The student must display proficiency in the fundamental operational skills required to **operate** an spreadsheet.

DOMAIN DEFINITION

Spreadsheet operational principles include competence in the following operational tasks:

position the cursor at specified cells as well as move it freely with the cursor control keys

read and respond appropriately to the spreadsheet indicators

activate and use the help screens

assess whether the spreadsheet is ready to receive data or not

distinguish between global and range settings

describe a range of cells in spreadsheet format

understand and use spreadsheet terminology

recognise a function identifier (@)

identify and select graph types

save and retrieve spreadsheet and graph image files

identify and select ranges for printing

OBJECTIVE 2: DATA ENTRY

The student must be able to enter, recognise and use data in its various spreadsheet formats.

DOMAIN DEFINITION

In assessing Data Entry evidence is required of the student's ability to:

identify embedded justification codes

distinguish between value & label entries

apply the justification rules to label and value entries

enter data as arithmetic expressions and know operator hierarchies

use cell addresses in algebraic procedures

select data ranges for graph input and generation

OBJECTIVE 3: FORMATTING

The student must be able apply formatting procedures to a spreadsheet in order to ensure that the correct numeric notations are used and that the spreadsheet is easily interpreted.

DOMAIN DEFINITION

In assessing 'Formatting' evidence is required of the student's ability to:

justify a range of label entries

use 'cell fill' for layout purposes

remove rows and columns

insert rows and columns

format numerical entries

set column widths

identify illegal data formats

OBJECTIVE 4: FUNCTIONS

The student must be able to use functions in the place of lengthy arithmetic statements.

DOMAIN DEFINITION

In assessing 'Functions' evidence is required of the student's ability to:

know the operational tasks of the functions @sum, @count, @avg, @max, @min

identify when it is practically advantageous to use functions instead of discrete cell algebra

assign correct and meaningful cell ranges to functions

OBJECTIVE 5: COPY

The student must be able to copy from specified source ranges to destination ranges and understand the relative range adaptations which occur in the process

DOMAIN DEFINITION

In assessing 'Copy' evidence is required of the student's ability to:

identify relative cell changes in destination ranges

apply absolute addressing when needed

generate aesthetic features using copy

OBJECTIVE 6: WHAT IF

The student must be able to understand the links which enable what-if analysis to be done

DOMAIN DEFINITION

In assessing 'What If' evidence is required of the student's ability to:

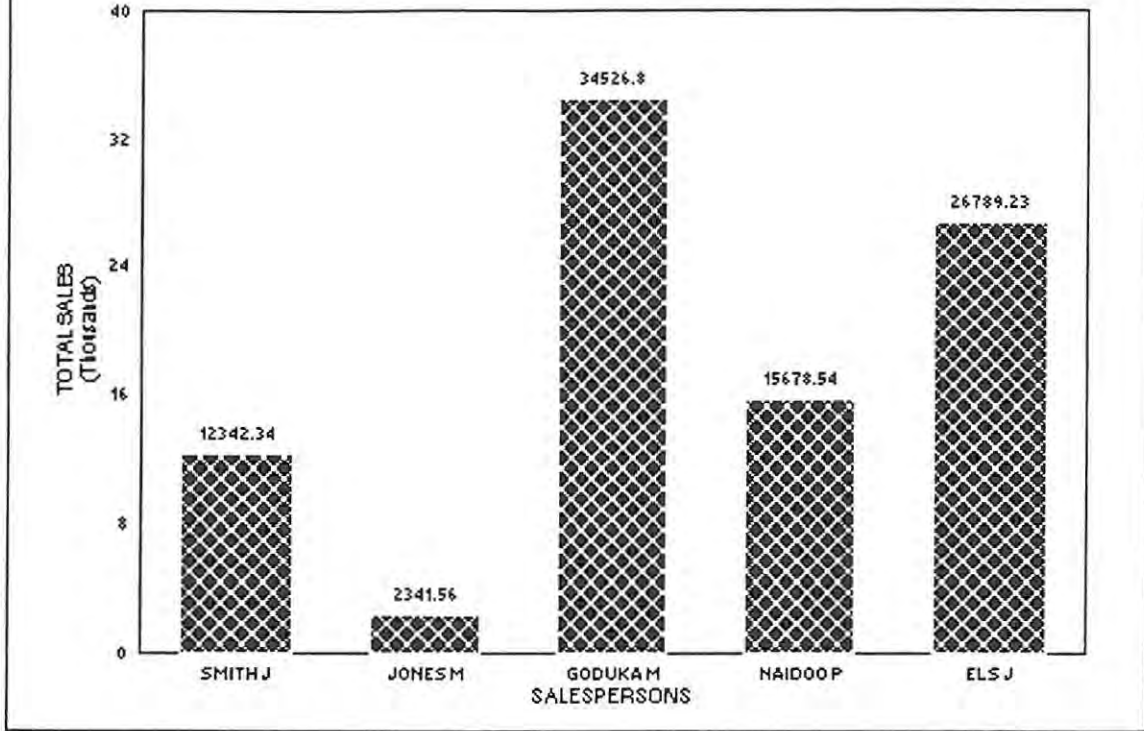
identify independent and dependent cells

manipulate independent data so as to keep dependent data within constraints

APPENDIX B: SPREADSHEET TEST TEMPLATE

1	A	B	C	D	E	F	G
1		SALESPERSON PERFORMANCE FOR JULY 1992					
2							
3							
4	HOURLY RATE			16.45			
5	TOTAL BASIC SALARY BILL			11005.05			
6	TOTAL BASIC SALARY BUDGET			13000.00			
7							
8				SALES PERSONNEL			
9							
10							
11		SMITH J	JONES M	GODUKA M	NAIDOO P	ELS J	TOTALS
12	=====	=====	=====	=====	=====	=====	=====
13	ITEM						
14	=====	=====	=====	=====	=====	=====	=====
15	HOURS WORKED	123	136	128	145	137	669
16	BASIC SALARY	2023.35	2237.2	2105.6	2385.25	2253.65	11005.05
17	TOTAL SALES	12342.34	2341.56	34526.8	15678.54	26789.23	91678.47
18	COMMISSION RATE	5	7	6	4	5	27
19	COMMISSION	617.117	163.9092	2071.608	627.1416	1339.4615	4819.2373
20							
21	=====	=====	=====	=====	=====	=====	
22	GROSS	2640.467	2401.1092	4177.208	3012.3916	3593.1115	15824.2873
23							
24							
25	TOTAL SALES		*****				
26	AVERAGE SALES		@AVGB18..E18				
27	BEST SALES PERFORMANCE						
28	WORST SALES PERFORMANCE						

SALESPERSON PERFORMANCE FOR JULY



APPENDIX C: A CRITERION-REFERENCED TEST FOR ASSESSING
PRIMARY SPREADSHEET SKILLS.

QUESTION MARK

17/45

The quickest way to ensure that the cursor is in cell A1 is to press

1	END
2	PAGE DOWN
3	PAGE UP
4	HOME
5	CTRL and ---->
6	CTRL and <----

LOTUS BEGINNER Time remaining 1:30:46

Press one of 1 to 6.

Press ? to answer later. Press ESC to finish.

QUESTION MARK

27/45

As the CURSOR is moved about the worksheet area the STATUS LINE changes showing the current location of the cursor.

1	True
2	False

Editing - Begin3 Trying out question

Press one of 1 or 2.

Press ? to answer later. Press ESC to finish.

QUESTION MARK

3/45

Help can be obtained at any time by pressing the **-----** key.

Editing - Begin3 Trying out question

Type your answer in the gap in the question wording, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

4/45

The indicator in the top right hand corner of the screen which indicates whether or not the worksheet is ready to receive data into the current cell is known as the:

1	MODE INDICATOR
2	CELL CONTENTS INDICATOR
3	STATUS INDICATOR
4	CELL INDICATOR

Editing - Begin3 Trying out question

Press one of 1 to 4.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

5/45

If "TEXT

is entered into a cell, then the word TEXT will be displayed on the
_____ hand side of the cell.

LOTUS BEGINNER Time remaining 1:29:24

Type your answer in the gap in the question wording, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

6/45

Which THREE of the following are VALUE entries when entered into a
lotus cell?

A	"25 August 1992
B	7-Sep-91
C	4*6
D	'+16/4
E	+16/4
F	(56-23)+4

LOTUS BEGINNER Time remaining 1:29:10

Select those answers that apply by pressing the letters # to f.
To de-select, press the letter again. When you are satisfied, press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

7/45

Which ONE of the following statements is TRUE?

- 1 A Global setting affects a column, row, cell or group of cells within a worksheet.
- 2 A Range setting affects only entire rows or columns of a worksheet.
- 3 A Global setting affects the entire worksheet.
- 4 A Range setting affects the entire worksheet.

LOTUS BEGINNER Time remaining 1:27:21

Press one of 1 to 4.

Press ? to answer later. Press ESC to finish.

QUESTION MARK

8/45

A range of cells has been shown alongside.

How is this range described using Lotus notation?

	A	B	C
1			
2			

LOTUS BEGINNER Time remaining 1:27:03

Type your answer as a single word, and press Enter.

Press ? to answer later. Press ESC to finish.

QUESTION MARK

9/45

Labels can be placed on the right, left or in the centre of a cell.
What is this process called where we POSITION label entries within
cells?

LOTUS BEGINNER Time remaining 1:26:49

Type your answer as a single word, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

10/45

All functions in lotus are preceded by a certain operator which
indicates to the programme that what follows is a function. What is
this operator or symbol?

LOTUS BEGINNER Time remaining 1:26:29

Type your answer as a single word, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

11/45

@count(b20..b35)

can be used to find the number of numerical entries in the range b20..b35.

1	True
2	False

LOTUS BEGINNER Time remaining 1:26:06

Press one of 1 or 2.

Press ? to answer later. Press ESC to finish.

QUESTION MARK

12/45

Write a shorter LOTUS statement which will do the following task:

+d4+d5+d6+d7+d8+d9+d10+d11+d12+d13+d14+d15

where d4 to d15 are all cell references.

LOTUS BEGINNER Time remaining 1:25:43

Type your answer as a single word, and press Enter.

Press ? to answer later. Press ESC to finish.

QUESTION MARK

13/45

@avg(b12..e12) calculates the of the cell entries b12 to e12.

LOTUS BEGINNER Time remaining 1:25:27

Type your answer in the gap in the question wording, and press Enter.
 Press ? to answer later. Press ESC to finish.

QUESTION MARK

14/45

Which of the following will be displayed when
 20/4/5
 is entered into a cell exactly as shown?

1	ERR
2	"20/4/5
3	'20/4/5
4	20/4/5
5	25
6	1

LOTUS BEGINNER Time remaining 1:25:08

Press one of 1 to 6.
 Press ? to answer later. Press ESC to finish.

QUESTION MARK	
15/45	*** REFER TO YOUR WORKSHEET! ***
<p>The names of the salespersons do not line up properly with the values listed below them. Which of the following sets of keystrokes would be best suited to aligning the names with the numeric entries.</p>	
1	/rlrb15..f22 and ENTER
2	/rllb11..f11 and ENTER
3	/rlcb11..f11 and ENTER
4	/rlrb11..f11 and ENTER
5	/rllb15..f22 and ENTER
6	/rlcb15..f22 and ENTER
<p>Editing - Begin2 Trying out question</p> <p>Press ? to answer later. Press one of 1 to 6. Press ESC to finish.</p>	

QUESTION MARK	
16/45	The entry for cell A12 is
<p>=====</p>	
<p>Which of the following would be the quickest way of achieving this entry?</p>	
1	'=====
2	\=
3	'=
4	"=
5	=====
6	^=
<p>LOTUS BEGINNER Time remaining 1:24:15</p> <p>Press ? to answer later. Press one of 1 to 6. Press ESC to finish.</p>	

QUESTION MARK

17/45

Consider the following range of cells with the entries shown inside each cell. The cursor is in cell B2 which is empty. What would be displayed in cell B2 after the following entry is made?
 $(a1+b1)/a2$

	A	B	C
row1	4	6	7
row2	5		2

LOTUS BEGINNER Time remaining 1:23:14

Type your answer as a number, and press Enter.
 If you need to, you can use floating point numbers, eg "1.3E23" or "-1E6".
 Press ? to answer later. Press ESC to finish.

QUESTION MARK

18/45

Consider the following range of cells with the entries shown inside each cell. The cursor is in cell B2 which is empty. What would be displayed in cell B2 after the following entry is made?
 $+b1*c1+100$

	A	B	C
row1	4	6	
row2	5		2

LOTUS BEGINNER Time remaining 1:23:00

Type your answer as a number, and press Enter.
 If you need to, you can use floating point numbers, eg "1.3E23" or "-1E6".
 Press ? to answer later. Press ESC to finish.

QUESTION MARK													
19/45	*** REFER TO YOUR WORKSHEET! ***												
<p>The value in cell D19 is shown. This is the commission which must be paid to M GODUKA. It is calculated by using the COMMISSION RATE for GODUKA which is 6% and his TOTAL SALES for the MONTH. The calculation is therefore 6% of TOTAL SALES for GODUKA. Which three of the following formulae could have been used to do the job?</p>													
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>A</td><td>$+D17*D18/100$</td></tr> <tr><td>B</td><td>$+D18/100*D17$</td></tr> <tr><td>C</td><td>$+D17*100/D18$</td></tr> <tr><td>D</td><td>$+D18*100/D17$</td></tr> <tr><td>E</td><td>$(D17*D18)/100$</td></tr> <tr><td>F</td><td>$(D17*100)/D18$</td></tr> </table>	A	$+D17*D18/100$	B	$+D18/100*D17$	C	$+D17*100/D18$	D	$+D18*100/D17$	E	$(D17*D18)/100$	F	$(D17*100)/D18$	
A	$+D17*D18/100$												
B	$+D18/100*D17$												
C	$+D17*100/D18$												
D	$+D18*100/D17$												
E	$(D17*D18)/100$												
F	$(D17*100)/D18$												
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">LOTUS BEGINNER</td> <td style="text-align: right;">Time remaining 1:22:46</td> </tr> <tr> <td colspan="2" style="text-align: center;"> Select those answers that apply by pressing the letters A to F. To de-select, press the letter again. When you are satisfied, press Enter. Press ? to answer later. Press ESC to finish. </td> </tr> </table>		LOTUS BEGINNER	Time remaining 1:22:46	Select those answers that apply by pressing the letters A to F. To de-select, press the letter again. When you are satisfied, press Enter. Press ? to answer later. Press ESC to finish.									
LOTUS BEGINNER	Time remaining 1:22:46												
Select those answers that apply by pressing the letters A to F. To de-select, press the letter again. When you are satisfied, press Enter. Press ? to answer later. Press ESC to finish.													

QUESTION MARK													
20/45	*** REFER TO YOUR WORKSHEET ***												
<p>What is the correct sequence of events in order to delete the TOTALS column (column G)?</p>													
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>A</td><td>Select Worksheet</td></tr> <tr><td>B</td><td>Select Column</td></tr> <tr><td>C</td><td>Move to a cell in column G</td></tr> <tr><td>D</td><td>Select Delete</td></tr> <tr><td>E</td><td>Press /</td></tr> <tr><td>F</td><td>Press Enter</td></tr> </table>	A	Select Worksheet	B	Select Column	C	Move to a cell in column G	D	Select Delete	E	Press /	F	Press Enter	
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<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">LOTUS BEGINNER</td> <td style="text-align: right;">Time remaining 1:22:06</td> </tr> <tr> <td colspan="2" style="text-align: center;"> Assign a number from 1 to 6 to each answer. Press F10 when your answer is ready. Move to each line with the arrow keys or by typing its letter. Press ? to answer later. Press ESC to finish. </td> </tr> </table>		LOTUS BEGINNER	Time remaining 1:22:06	Assign a number from 1 to 6 to each answer. Press F10 when your answer is ready. Move to each line with the arrow keys or by typing its letter. Press ? to answer later. Press ESC to finish.									
LOTUS BEGINNER	Time remaining 1:22:06												
Assign a number from 1 to 6 to each answer. Press F10 when your answer is ready. Move to each line with the arrow keys or by typing its letter. Press ? to answer later. Press ESC to finish.													

QUESTION MARK									
21/45	<p style="text-align: center;">*** REFER TO YOUR WORKSHEET ***</p> <p>What would be the correct sequence of keystrokes to use in order to format every numerical entry in the spreadsheet to 2 decimal places?</p>								
<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 5%; text-align: center; padding: 2px;">1</td> <td style="padding: 2px;">/Worksheet Range Format Fixed 2 and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">2</td> <td style="padding: 2px;">/Worksheet Global Format Fixed 2 and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">3</td> <td style="padding: 2px;">/Worksheet Global Format Fixed 2 Enter b15..f22 and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">4</td> <td style="padding: 2px;">/Worksheet Range Format Fixed 2 Enter b15..f22 and ENTER</td> </tr> </tbody> </table>	1	/Worksheet Range Format Fixed 2 and ENTER	2	/Worksheet Global Format Fixed 2 and ENTER	3	/Worksheet Global Format Fixed 2 Enter b15..f22 and ENTER	4	/Worksheet Range Format Fixed 2 Enter b15..f22 and ENTER	
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4	/Worksheet Range Format Fixed 2 Enter b15..f22 and ENTER								
Editing - Begin3 Trying out question									
<p style="text-align: center;">Press one of 1 to 4.</p> <p>Press ? to answer later. Press ESC to finish.</p>									

QUESTION MARK													
22/45	<p style="text-align: center;">*** REFER TO THE WORKSHEET ***</p> <p>Column A has been set to a width of 15 characters. Which of the following was the most likely set of keystrokes used in order to do this? Assume that the cursor is in column A to begin with.</p>												
<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 5%; text-align: center; padding: 2px;">1</td> <td style="padding: 2px;">/Worksheet Column Setwidth 15 and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">2</td> <td style="padding: 2px;">/Worksheet Column 15 Setwidth and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">3</td> <td style="padding: 2px;">/Worksheet Column Setwidth and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">4</td> <td style="padding: 2px;">/Worksheet Global Column and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">5</td> <td style="padding: 2px;">/Worksheet Global Column Setwidth 15 and ENTER</td> </tr> <tr> <td style="text-align: center; padding: 2px;">6</td> <td style="padding: 2px;">/Worksheet Global 15 Column Setwidth and ENTER</td> </tr> </tbody> </table>	1	/Worksheet Column Setwidth 15 and ENTER	2	/Worksheet Column 15 Setwidth and ENTER	3	/Worksheet Column Setwidth and ENTER	4	/Worksheet Global Column and ENTER	5	/Worksheet Global Column Setwidth 15 and ENTER	6	/Worksheet Global 15 Column Setwidth and ENTER	
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Editing - Begin3 Trying out question													
<p style="text-align: center;">Press one of 1 to 6.</p> <p>Press ? to answer later. Press ESC to finish.</p>													

QUESTION MARK

23/45

Cell entries can be either

1. LABEL or 2. VALUE

Mark the following items as LABEL or VALUE entries by placing a
 1 for LABEL or a 2 for VALUE
 next to each item.

A	(45+30)	
B	6/*a34+a25	
C	*45	
D	"2 August 1992	
E	number	
F	a23+b45	

LOTUS BEGINNER Time remaining 1:20:53

Assign a number from 1 to 6 to each answer. Press F10 when your answer is ready.
 Move to each line with the arrow keys or by typing its letter.
 Press ? to answer later. Press ESC to finish.

QUESTION MARK

24/45

*** REFER TO THE WORKSHEET ***

Match the values shown below with the following cell entries:
 (assume that entries are made in unused cells)

1. @count(b22..f22)	2. @max(b15..f15)	3. @min(b18..f18)
4. @sum(b22..f22)	5. @avg(b15..f15)	6. @sum(b18..f18)

A	6	
B	27	
C	5	
D	145	

LOTUS BEGINNER Time remaining 1:20:36

Assign a number from 1 to 6 to each answer. Press F10 when your answer is ready.
 Move to each line with the arrow keys or by typing its letter.
 Press ? to answer later. Press ESC to finish.

QUESTION MARK											
25/45	*** REFER TO THE WORKSHEET ***										
<p>The cursor is in cell A1. The menu has been activated.</p> <p>You are now required to format the numeric entries for salesman ELS to 0 decimal places. What is the correct sequence of events?</p>											
<table border="1"> <tr> <td>A</td> <td>type 0 and then ENTER</td> </tr> <tr> <td>B</td> <td>type F15..F22 and then Enter</td> </tr> <tr> <td>C</td> <td>select RANGE</td> </tr> <tr> <td>D</td> <td>select FORMAT</td> </tr> <tr> <td>E</td> <td>select FIXED</td> </tr> </table>	A	type 0 and then ENTER	B	type F15..F22 and then Enter	C	select RANGE	D	select FORMAT	E	select FIXED	
A	type 0 and then ENTER										
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<table border="1"> <tr> <td> LOTUS BEGINNER </td> <td> Time remaining 1:20:21 </td> </tr> <tr> <td colspan="2"> Assign a number from 1 to 5 to each answer. Press F10 when your answer is ready. </td> </tr> <tr> <td colspan="2"> Move to each line with the arrow keys or by typing its letter. </td> </tr> <tr> <td> Press ? to answer later. </td> <td> Press ESC to finish. </td> </tr> </table>		LOTUS BEGINNER	Time remaining 1:20:21	Assign a number from 1 to 5 to each answer. Press F10 when your answer is ready.		Move to each line with the arrow keys or by typing its letter.		Press ? to answer later.	Press ESC to finish.		
LOTUS BEGINNER	Time remaining 1:20:21										
Assign a number from 1 to 5 to each answer. Press F10 when your answer is ready.											
Move to each line with the arrow keys or by typing its letter.											
Press ? to answer later.	Press ESC to finish.										

QUESTION MARK													
26/45													
<p>Which two of the following are illegal cell entries when entered exactly as shown below:</p>													
<table border="1"> <tr> <td>A</td> <td>(c15+c12)</td> </tr> <tr> <td>B</td> <td>+C4</td> </tr> <tr> <td>C</td> <td>"(cats + dogs) = pets</td> </tr> <tr> <td>D</td> <td>*** TODAY ***</td> </tr> <tr> <td>E</td> <td>5 AUGUST 1992</td> </tr> <tr> <td>F</td> <td>*9 Springbok Road</td> </tr> </table>	A	(c15+c12)	B	+C4	C	"(cats + dogs) = pets	D	*** TODAY ***	E	5 AUGUST 1992	F	*9 Springbok Road	
A	(c15+c12)												
B	+C4												
C	"(cats + dogs) = pets												
D	*** TODAY ***												
E	5 AUGUST 1992												
F	*9 Springbok Road												
<table border="1"> <tr> <td> LOTUS BEGINNER </td> <td> Time remaining 1:19:51 </td> </tr> <tr> <td colspan="2"> Select those answers that apply by pressing the letters A to F. </td> </tr> <tr> <td colspan="2"> To de-select, press the letter again. When you are satisfied, press Enter. </td> </tr> <tr> <td> Press ? to answer later. </td> <td> Press ESC to finish. </td> </tr> </table>		LOTUS BEGINNER	Time remaining 1:19:51	Select those answers that apply by pressing the letters A to F.		To de-select, press the letter again. When you are satisfied, press Enter.		Press ? to answer later.	Press ESC to finish.				
LOTUS BEGINNER	Time remaining 1:19:51												
Select those answers that apply by pressing the letters A to F.													
To de-select, press the letter again. When you are satisfied, press Enter.													
Press ? to answer later.	Press ESC to finish.												

QUESTION MARK

27/45

***** REFER TO YOUR WORKSHEET *****

The cell entry for C26 is shown. It was intended that this cell display the AVERAGE SALES of all the salesmen. (In other words, the average of the row TOTAL SALES.)

The cell entry for C26 is WRONG. What should it be?

LOTUS BEGINNER Time remaining 1:19:35

Type your answer as a single word, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

28/45

***** REFER TO THE WORKSHEET *****

If $\text{@max}(b17..f17)$ is entered into cell C27, what will be displayed in this cell?

LOTUS BEGINNER Time remaining 1:19:22

Type your answer as a number, and press Enter.
If you need to, you can use floating point numbers, eg "1.3E23" or "-1E6".
Press ? to answer later. Press ESC to finish.

QUESTION MARK

29/45

***** REFER TO THE WORKSHEET *****

If @min(Cb17..f17) is the cell entry for cell C28, what will be displayed in this cell?

LOTUS BEGINNER Time remaining 1:19:10

Type your answer as a number, and press Enter.
If you need to, you can use floating point numbers, eg "1.3E23" or "-1E6".
Press ? to answer later. Press ESC to finish.

QUESTION MARK

30/45

***** REFER TO THE WORKSHEET *****

To calculate the GROSS for each salesperson, the formula used was

BASIC SALARY + COMMISSION

What should the cell entry be for NAIDOO's gross?

Editing - Begin2 Trying out question

Type your answer as a single word, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK			
31/45	*** REFER TO THE WORKSHEET ***		
STATEMENT: The entry for cell C25 was @sum(b17..f17). The display is ***** because column C is too narrow.			
ACTION TO BE TAKEN: The entry must be formatted to fewer decimal places in order for the value to be displayed.			
1	The STATEMENT is correct and the proposed ACTION is correct.		
2	The STATEMENT is correct but the proposed ACTION is wrong.		
3	The STATEMENT is wrong and the ACTION to be taken is wrong.		
4	The STATEMENT is wrong but the ACTION to be taken is correct.		
<table border="1"> <tr> <td>LOTUS BEGINNER</td> <td>Time remaining 1:18:35</td> </tr> </table>		LOTUS BEGINNER	Time remaining 1:18:35
LOTUS BEGINNER	Time remaining 1:18:35		
Press one of 1 to 4.			
Press ? to answer later.	Press ESC to finish.		

QUESTION MARK			
32/45	*** REFER TO THE WORKSHEET ***		
The cell entry for cell G15 is @sum(b15..f15). The copy command was then used to copy this formula from cell G15 to the range G16..G17.			
If the cursor is later moved to cell G17, what will the cell contents indicator show?			
1	669		
2	91678.47		
3	@SUM(B15..F15)		
4	@SUM(B17..F17)		
<table border="1"> <tr> <td>LOTUS BEGINNER</td> <td>Time remaining 1:18:22</td> </tr> </table>		LOTUS BEGINNER	Time remaining 1:18:22
LOTUS BEGINNER	Time remaining 1:18:22		
Press one of 1 to 4.			
Press ? to answer later.	Press ESC to finish.		

QUESTION MARK	
33/45	*** REFER TO YOUR WORKSHEET ***
The BASIC SALARY for each salesperson is calculated using the formula BASIC SALARY = HOURS WORKED * HOURLY PAY RATE	
What formula should be used to calculate the BASIC salary for SMITH in cell B16 if this formula is to be copied for the rest of the salespersons (range C16..F16)?	
<input style="width: 150px; height: 20px;" type="text"/>	
Editing - Begin2 Trying out question	
Type your answer as a single word, and press Enter.	Press ESC to finish.
Press ? to answer later.	

QUESTION MARK	
34/45	*** REFER TO THE WORKSHEET ***
(B15*D4) was used as the cell entry for cell B16	
This formula was then copied from cell B16 to the range C16..F16.	
What will the cell CONTENTS for cell E16 be after this has been done?	
<input style="width: 150px; height: 20px;" type="text"/>	
LOTUS BEGINNER	
Time remaining 1:17:54	
Type your answer as a single word, and press Enter.	Press ESC to finish.
Press ? to answer later.	

QUESTION MARK	
35/45	*** REFER TO THE WORKSHEET ***
<p>There is a line drawn across the worksheet just above the GROSS row. (the = sign has been used).</p> <p>What is the correct sequence of events to copy this line just below the GROSS row?</p>	
A	Activate the menu by pressing / and select COPY
B	Type A24..G24 and press ENTER
C	Type A21..G21 and press ENTER
<p>LOTUS BEGINNER Time remaining 1:17:41</p> <p>Assign a number from 1 to 3 to each answer. Press F10 when your answer is ready. Move to each line with the arrow keys or by typing its letter. Press ? to answer later. Press ESC to finish.</p>	

QUESTION MARK	
36/45	
<p>When we conduct WHAT IF ANALYSIS using a spreadsheet, we are looking to see what effect changes in independent data have upon models (formulae) using this data.</p>	
1	False
2	True
<p>LOTUS BEGINNER Time remaining 1:17:19</p> <p>Press one of 1 or 2. Press ? to answer later. Press ESC to finish.</p>	

QUESTION MARK					
37/45					
*** REFER TO YOUR SPREADSHEET ***					
<p>BASIC SALARY for each salesperson = HOURS WORKED * HOURLY RATE and TOTAL BASIC SALARY BILL = THE SUM of all the BASIC SALARY entries.</p> <p>Given the above information, is it true that an increase in the value in cell D4 will cause a decrease in the value shown in cell B5?</p>					
<table border="1"> <tr> <td>1</td> <td>Yes</td> </tr> <tr> <td>2</td> <td>No</td> </tr> </table>	1	Yes	2	No	
1	Yes				
2	No				
Editing - Begin2 Trying out question					
Press one of 1 or 2.					
Press ? to answer later.	Press ESC to finish.				

QUESTION MARK	
38/45	
*** REFER TO THE WORKSHEET ***	
<p>BASIC SALARY (for each salesperson) = HOURS WORKED * HOURLY RATE TOTAL BASIC SALARY BILL = The sum of the BASIC SALARY for all salespers. TOTAL BASIC SALARY BUDGET is the maximum BASIC SALARY BILL allowed. If the HOURLY RATE is increased to 21.00, what other action will have to be taken in order to keep within the TOTAL BASIC SALARY BUDGET, R13000?</p>	
Editing - Begin2 Trying out question	
Type your answer in the box (using the arrow keys to move the cursor).	
Press the F10 key when your answer is complete.	
Press ? to answer later.	Press ESC to finish.

QUESTION MARK

39/45

When printing a worksheet, the first thing to be done after activating the printing menu is to mark the which must be printed out.

LOTUS BEGINNER Time remaining 1:15:41

Type your answer in the gap in the question wording, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK

40/45



*** REFER TO THE WORKSHEET ***

What range would have to be marked if the entire spreadsheet is to be printed out?

LOTUS BEGINNER Time remaining 1:15:27

Type your answer as a single word, and press Enter.
Press ? to answer later. Press ESC to finish.

QUESTION MARK	
41/45	
*** REFER TO THE GRAPH ***	
What type of graph is this?	
1	PIE
2	STACKED BAR
3	XY
4	BAR
5	LINE
6	EXPLODED PIE
LOTUS BEGINNER Time remaining 1:15:01	
Press one of 1 to 6.	
Press ? to answer later. Press ESC to finish.	

QUESTION MARK	
42/45	
*** REFER TO THE GRAPH ***	
TOTAL SALES has been used as the range for the  -axis and SALESPERSONNEL as the range for the  -axis.	
Editing - Begin2 Trying out question	
Fill in the gaps in the question wording, using Enter or Tab to change gaps.	
Press the F10 key when your answer is complete.	
Press ? to answer later. Press ESC to finish.	

QUESTION MARK													
43/45													
*** REFER TO THE GRAPH ***													
Which set of keystrokes (or menu selections and commands) could be used to place the data values above each bar.													
<table border="1"> <tbody> <tr><td>1</td><td>/gab17..f17 enter centre</td></tr> <tr><td>2</td><td>/godab17..f17 enter a</td></tr> <tr><td>3</td><td>/gab17..f17 enter above</td></tr> <tr><td>4</td><td>/Graph Options Data-labels A b17..f17 enter Centre</td></tr> <tr><td>5</td><td>/Graph A b17..f17 enter Above</td></tr> <tr><td>6</td><td>/Graph Options Data-labels A b17..f17 enter Above</td></tr> </tbody> </table>	1	/gab17..f17 enter centre	2	/godab17..f17 enter a	3	/gab17..f17 enter above	4	/Graph Options Data-labels A b17..f17 enter Centre	5	/Graph A b17..f17 enter Above	6	/Graph Options Data-labels A b17..f17 enter Above	
1	/gab17..f17 enter centre												
2	/godab17..f17 enter a												
3	/gab17..f17 enter above												
4	/Graph Options Data-labels A b17..f17 enter Centre												
5	/Graph A b17..f17 enter Above												
6	/Graph Options Data-labels A b17..f17 enter Above												
<table border="1"> <thead> <tr> <th>LOTUS BEGINNER</th> <th>Time remaining 1:14:37</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Press one of 1 to 6.</td> <td></td> </tr> <tr> <td>Press ? to answer later.</td> <td style="text-align: right;">Press ESC to finish.</td> </tr> </tbody> </table>		LOTUS BEGINNER	Time remaining 1:14:37	Press one of 1 to 6.		Press ? to answer later.	Press ESC to finish.						
LOTUS BEGINNER	Time remaining 1:14:37												
Press one of 1 to 6.													
Press ? to answer later.	Press ESC to finish.												

QUESTION MARK							
44/45							
When working with graphs there are two specific types of SAVE which can be done. What must be saved in order to PRINT the graph later with PRINTGRAPH?							
<div style="border: 1px solid black; height: 80px; width: 100%;"></div>							
<table border="1"> <thead> <tr> <th>LOTUS BEGINNER</th> <th>Time remaining 1:14:26</th> </tr> </thead> <tbody> <tr> <td colspan="2" style="text-align: center;">Type your answer in the box (using the arrow keys to move the cursor). Press the F10 key when your answer is complete.</td> </tr> <tr> <td>Press ? to answer later.</td> <td style="text-align: right;">Press ESC to finish.</td> </tr> </tbody> </table>		LOTUS BEGINNER	Time remaining 1:14:26	Type your answer in the box (using the arrow keys to move the cursor). Press the F10 key when your answer is complete.		Press ? to answer later.	Press ESC to finish.
LOTUS BEGINNER	Time remaining 1:14:26						
Type your answer in the box (using the arrow keys to move the cursor). Press the F10 key when your answer is complete.							
Press ? to answer later.	Press ESC to finish.						

QUESTION MARK

45745

*** REFER TO YOUR GRAPH ***

Match the following ranges with the descriptions shown below.

1. B11..F11 2. B17..F17 3. B19..F19

You may use a range more than once!

A	X-range	
B	Data labels for the A-range	
C	A-range	

LOTUS BEGINNER Time remaining 1:14:10

Assign a number from 1 to 3 to each answer. Press F10 when your answer is ready.
Move to each line with the arrow keys or by typing its letter.
Press ? to answer later. Press ESC to finish.

**APPENDIX D: THE AGREEMENT STATISTICS FOR THE
INDIVIDUAL TEST ITEMS (cut-score = 25)**

ITEM	MASTER		NONMASTERS		TOTAL	AGREEMENT STATISTIC	AGREEMENT STATISTIC LOWER BOUND	AGREEMENT STATISTIC - LOWER BOUND
	CORRECT	INCORRECT	CORRECT	INCORRECT				
1	65	1	30	2	98	0.68	0.66	0.02
2	52	14	13	19	98	0.72	0.56	0.17
3	61	5	24	8	98	0.70	0.63	0.08
4	57	9	20	12	98	0.70	0.60	0.10
5	56	10	28	4	98	0.61	0.62	-0.01
6	36	30	8	24	98	0.61	0.48	0.13
7	62	4	24	8	98	0.71	0.63	0.08
8	28	38	4	28	98	0.57	0.44	0.13
9	55	11	22	10	98	0.66	0.60	0.06
10	32	34	3	29	98	0.62	0.45	0.17
11	55	11	27	5	98	0.61	0.62	0.00
12	60	6	15	17	98	0.79	0.59	0.19
13	62	4	23	9	98	0.72	0.63	0.10
14	21	45	3	29	98	0.51	0.41	0.10
15	43	23	9	23	98	0.67	0.51	0.16
16	62	4	24	8	98	0.71	0.63	0.08
17	58	8	24	8	98	0.67	0.62	0.06
18	45	21	17	15	98	0.61	0.55	0.07
19	26	40	6	26	98	0.53	0.44	0.09
20	28	38	8	24	98	0.53	0.45	0.08
21	51	15	13	19	98	0.71	0.55	0.16
22	48	18	17	15	98	0.64	0.56	0.09
23	16	50	2	30	98	0.47	0.39	0.08
24	57	9	16	16	98	0.74	0.58	0.16
25	2	64	1	31	98	0.34	0.34	0.00
26	8	58	1	31	98	0.40	0.36	0.04
27	47	19	7	25	98	0.73	0.52	0.22
28	54	12	14	18	98	0.73	0.57	0.17
29	56	10	9	23	98	0.81	0.56	0.25
30	42	24	8	24	98	0.67	0.50	0.17
31	33	33	10	22	98	0.56	0.48	0.08
32	44	22	8	24	98	0.69	0.51	0.18
33	14	52	1	31	98	0.46	0.38	0.08
34	2	64	0	32	98	0.35	0.33	0.01
35	48	18	13	19	98	0.68	0.54	0.14
36	54	12	20	12	98	0.67	0.59	0.08

37	55	11	25	7	98	0.63	0.61	0.02
38	17	49	2	30	98	0.48	0.39	0.09
39	64	2	23	9	98	0.74	0.63	0.11
40	33	33	9	23	98	0.57	0.48	0.10
41	64	2	28	4	98	0.69	0.65	0.04
42	49	17	18	14	98	0.64	0.56	0.08
43	58	8	15	17	98	0.77	0.58	0.18
44	38	28	7	25	98	0.64	0.49	0.16
45	22	44	3	29	98	0.52	0.42	0.11

APPENDIX E: ITEM CONTENT REVIEW FORM

REVIEWER:

DATE

First read carefully through the list of domain specifications and test items. Next, please indicate how well you feel each item reflects the domain specification it was written to measure. Judge a test item solely on the basis of the match between its contents and the content defined by the domain specification that the test item was prepared to measure. Please use the five-point rating scale shown below:

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

Circle the number corresponding to your rating beside the test item number.

Objective	Test Item	Item Rating				
1	1	1	2	3	4	5
	2	1	2	3	4	5
	3	1	2	3	4	5
	4	1	2	3	4	5
	7	1	2	3	4	5
	8	1	2	3	4	5
	9	1	2	3	4	5
	10	1	2	3	4	5
	39	1	2	3	4	5

	40	1	2	3	4	5
	41	1	2	3	4	5
	44	1	2	3	4	5
2	5	1	2	3	4	5
	6	1	2	3	4	5
	23	1	2	3	4	5
	14	1	2	3	4	5
	17	1	2	3	4	5
	18	1	2	3	4	5
	19	1	2	3	4	5
	30	1	2	3	4	5
	42	1	2	3	4	5
	43	1	2	3	4	5
	45	1	2	3	4	5
3	15	1	2	3	4	5
	16	1	2	3	4	5
	20	1	2	3	4	5
	21	1	2	3	4	5
	22	1	2	3	4	5
	25	1	2	3	4	5
	26	1	2	3	4	5
	31	1	2	3	4	5
4	11	1	2	3	4	5
	13	1	2	3	4	5
	12	1	2	3	4	5
	24	1	2	3	4	5
	27	1	2	3	4	5
	28	1	2	3	4	5
	29	1	2	3	4	5

5	32	1	2	3	4	5
	34	1	2	3	4	5
	33	1	2	3	4	5
	35	1	2	3	4	5
6	36	1	2	3	4	5
	37	1	2	3	4	5
	38	1	2	3	4	5

APPENDIX F: ITEM/OBJECTIVES CONGRUENCE REVIEW

OBJECTIVE	TEST ITEM	ITEM RATING			
		THYS	ANNERIE	LYNETTE	MEAN
1	1	5	5	5	5.0
	2	5	5	5	5.0
	3	5	5	5	5.0
	4	5	5	5	5.0
	7	5	5	5	5.0
	8	5	5	5	5.0
	9	4	5	5	4.7
	10	5	5	5	5.0
	39	3	5	5	4.3
	40	5	5	5	5.0
2	41	4	5	5	4.7
	44	3	5	5	4.3
	5	5	5	5	5.0
	6	5	5	5	5.0
	23	5	5	5	5.0
	14	5	5	5	5.0
	17	5	5	5	5.0
	18	5	5	5	5.0
	19	5	5	5	5.0
	30	5	5	5	5.0
3	42	5	5	5	5.0
	43	5	5	3	4.3
	45	5	5	5	5.0
	15	5	3	3	3.7
	16	5	5	5	5.0
	20	3	4	5	4.0
	21	5	3	3	3.7
	22	4	3	3	3.3
	25	5	4	5	4.7
	26	5	5	5	5.0
4	31	4	5	5	4.7
	11	4	5	5	4.7
	13	4	5	5	4.7
	12	5	5	5	5.0
	24	5	5	5	5.0
	27	5	5	5	5.0

	28	5	5	5	5.0
	29	5	5	5	5.0
5	32	5	5	5	5.0
	34	5	5	5	5.0
	33	5	4	5	4.7
	35	5	5	5	5.0
6	36	3	5	5	4.3
	37	5	5	5	5.0
	38	5	4	5	4.7

APPENDIX G: REPLACEMENT ITEMS

QUESTION MARK	
5/45	
What must be given as the data entry for the current cell if the word TAX is to be placed in the centre of this cell?	
<input type="text"/>	
Editing - Begin3 Trying out question	
Type your answer as a single word, and press Enter. Press ? to answer later. Press ESC to finish.	

QUESTION MARK	
15/45	
*** REFER TO YOUR WORKSHEET! ***	
The names of the salesmen do not line up properly with the values listed below them. Which of the following sets of keystrokes would be best suited to aligning the names with the numeric entries.	
1	/Range Label Right b15..f22 and ENTER
2	/Range Label Centre b11..f11 and ENTER
3	/Range Label Left b11..f11 and ENTER
4	/Range Label Right b11..f11 and ENTER
5	/Range Label Centre b15..f22 and ENTER
6	/Range Label Left b15..f22 and ENTER
Editing - Begin3 Trying out question	
Press one of 1 to 6. Press ? to answer later. Press ESC to finish.	

QUESTION MARK

22/45

*** REFER TO THE WORKSHEET ***

Column A has been set to a width of 15 characters. Which of the following was the most likely set of keystrokes used in order to do this? Assume that the cursor is in column A to begin with.

1	/Worksheet Column 15 Setwidth and ENTER
2	/Worksheet Column Setwidth and ENTER
3	/Worksheet Global Column and ENTER
4	/Worksheet Global Column Setwidth 15 and ENTER
5	/Worksheet Column Setwidth 15 and ENTER
6	/Worksheet Global 15 Column Setwidth and ENTER

Editing - Begin3 Trying out question

Press ? to answer later. Press one of 1 to 6. Press ESC to finish.

QUESTION MARK

21/45

*** REFER TO YOUR WORKSHEET ***

What would be the correct sequence of keystrokes to use in order to format every numerical entry in the spreadsheet to 2 decimal places?

1	/Worksheet Range Format Fixed 2 Enter b15..f22 and ENTER
2	/Worksheet Global Format Fixed 2 Enter b15..f22 and ENTER
3	/Worksheet Global Format Fixed 2 and ENTER
4	/Worksheet Range Format Fixed 2 and ENTER

Editing - Begin3 Trying out question

Press ? to answer later. Press one of 1 to 4. Press ESC to finish.

QUESTION MARK	
11/45	
Which of the following expressions can be used to find the number of numerical entries in the range b20..b35?	
1	@min(b20..b35)
2	@avg(b20..b35)
3	@sum(b20..b35)
4	@max(b20..b35)
5	@count(b20..b35)
Editing - Begin3 Trying out question	
Press one of 1 to 5.	
Press ? to answer later.	Press ESC to finish.

QUESTION MARK	
25/45	
*** REFER TO THE WORKSHEET ***	
The cursor is in cell A1.	
You are now required to format the numeric entries for salesman ELS to 0 decimal places. What is the correct sequence of events?	
A	select RANGE
B	/
C	type F15..F22 and then Enter
D	type 0 and then ENTER
E	select FIXED
F	select FORMAT
Editing - Begin3 Trying out question	
Assign a number from 1 to 6 to each answer. Press F10 when your answer is ready.	
Move to each line with the arrow keys or by typing its letter.	
Press ? to answer later.	Press ESC to finish.

**APPENDIX H: THE AGREEMENT STATISTICS FOR THE
INDIVIDUAL TEST ITEMS (cut-score = 31)**

ITEM	MASTERS		NONMASTERS		TOTAL	AGREEMENT STATISTIC	AGREEMENT STATISTIC LOWER BOUND	AGREEMENT STATISTIC - LOWER BOUND
	CORRECT	INCORRECT	CORRECT	INCORRECT				
1	51	0	29	0	98	0.52	0.42	0.10
2	46	5	18	11	98	0.58	0.39	0.19
3	50	1	27	2	98	0.53	0.42	0.11
4	50	1	24	5	98	0.56	0.41	0.15
5	35	16	12	17	98	0.53	0.35	0.18
6	45	6	16	13	98	0.59	0.38	0.21
7	51	0	25	4	98	0.56	0.42	0.15
8	43	8	13	16	98	0.60	0.37	0.23
9	49	2	26	3	98	0.53	0.41	0.12
10	45	6	12	17	98	0.63	0.37	0.26
11	51	0	28	1	98	0.53	0.42	0.11
12	50	1	21	8	98	0.59	0.40	0.19
13	50	1	28	1	98	0.52	0.42	0.10
14	47	4	19	10	98	0.58	0.39	0.19
15	46	5	23	6	98	0.53	0.40	0.13
16	51	0	28	1	98	0.53	0.42	0.11
17	51	0	24	5	98	0.57	0.41	0.16
18	48	3	20	9	98	0.58	0.40	0.18
19	42	9	7	22	98	0.65	0.35	0.30
20	23	28	9	20	98	0.44	0.31	0.12
21	48	3	15	14	98	0.63	0.39	0.25
22	43	8	23	6	98	0.50	0.39	0.11
23	40	11	10	19	98	0.60	0.36	0.25
24	48	3	21	8	98	0.57	0.40	0.17
25	0	51	0	29	98	0.30	0.24	0.05
26	17	34	7	22	98	0.40	0.30	0.10
27	43	8	7	22	98	0.66	0.36	0.31
28	49	2	23	6	98	0.56	0.41	0.15
29	47	4	26	3	98	0.51	0.41	0.10
30	42	9	16	13	98	0.56	0.37	0.19
31	42	9	17	12	98	0.55	0.38	0.17
32	24	27	7	22	98	0.47	0.31	0.16
33	8	43	0	29	98	0.38	0.26	0.12
34	0	51	0	29	98	0.30	0.24	0.05
35	44	7	19	10	98	0.55	0.39	0.17
36	36	15	17	12	98	0.49	0.36	0.13
37	36	15	24	5	98	0.42	0.38	0.04

38	19	32	4	25	98	0.45	0.29	0.15
39	51	0	26	3	98	0.55	0.42	0.13
40	46	5	13	16	98	0.63	0.38	0.26
41	48	3	26	3	98	0.52	0.41	0.11
42	47	4	17	12	98	0.60	0.39	0.21
43	44	7	20	9	98	0.54	0.39	0.15
44	42	9	19	10	98	0.53	0.38	0.15
45	27	24	2	27	98	0.55	0.31	0.24

APPENDIX I: OPINION SURVEY

Test : SURVEY

PLEASE ANSWER THE QUESTIONS HONESTLY. YOUR RESPONSE WILL HELP IMPROVE
THE TESTING SYSTEM!

Question number 1

Do you think it is fair to ask short questions about spreadsheets?

Circle one of the following :

- A No, not at all
- B No
- C I don't know
- D Yes
- E Yes, very fair

Question number 2

Did you enjoy writing the test?

Circle one of the following :

- A Definitely not
- B No
- C I didn't mind
- D I enjoyed the test
- E Yes, very much so

Question number 3

Do you enjoy writing your tests on computers?

Circle one of the following :

- A Definitely not
- B Not really

- C I don't mind
- D It's not a bad way to write tests
- E Yes, very much so

Question number 4

Do you wish that computers did not form a part of your course?

Circle one of the following :

- A Yes, definitely
- B It would be better without the computer work
- C I don't mind
- D I quite like the computer course
- E It is essential that I learn something about computers

Question number 5

Would you rather be tested by having to create a large spreadsheet on your own?

Circle one of the following :

- A Yes, definitely
- B It would be better
- C It would make no difference to me
- D No, I'd rather not
- E Definitely not

Question number 6

Were you at all nervous about writing this test?

Circle one of the following :

- A Very Nervous
- B Nervous
- C Indifferent
- D Not nervous
- E Definitely Not Nervous

Question number 7

Do you enjoy working with computers?

Circle one of the following :

- A No, I hate them
- B Not very much
- C I don't mind
- D I have a fair amount of enjoyment
- E I enjoy the work very much

Question number 8

Do you see yourself using a computer in your future career?

Circle one of the following :

- A Never
- B Only if I have to
- C I don't care
- D I'd like to
- E I see it as essential

Question number 9

Would you rather write this test using pencil and paper?

Circle one of the following :

- A Yes I definitely would
- B It would be better
- C I don't mind
- D No, I'd rather not
- E Definitely not

Question number 10

Do you think this was a fair test?

Circle one of the following :

- A Definitely Not
- B Not really
- C I don't know

- D It was reasonably fair
- E Yes, it was a very fair test

Quick reference summary of right answers for each question

1:	A:	1	B:	2	C:	3	D:	4	E:	5
2:	A:	1	B:	2	C:	3	D:	4	E:	5
3:	A:	1	B:	2	C:	3	D:	4	E:	5
4:	A:	1	B:	2	C:	3	D:	4	E:	5
5:	A:	1	B:	2	C:	3	D:	4	E:	5
6:	A:	1	B:	2	C:	3	D:	4	E:	5
7:	A:	1	B:	2	C:	3	D:	4	E:	5
8:	A:	1	B:	2	C:	3	D:	4	E:	5
9:	A:	1	B:	2	C:	3	D:	4	E:	5
10:	A:	1	B:	2	C:	3	D:	4	E:	5

APPENDIX J: ASSIGNMENT

You must set up a spreadsheet which enable SPLINTER'S WOODYARD to analyse their profit margins on their products. We will start with one product first and then include others.

The following information is vital to the spreadsheet and must be taken careful note of:

The cost of labour per hour is R17.85

The cost of transporting wood within the area of operation is R0.09 per kilogram

All costs, sales figures and other specifications quoted below are per cubic metre of wood.

STAGE 1

PINE is the most popular type of wood sold from this woodyard. The following information must be entered on the spreadsheet about this product:

The cost price per cubic metre is	R1254.87
The mass of pine per cubic metre is	451.00 kg
The handling time per cubic metre is	2.45 hours
The selling price of pine per cubic metre is	R1900.00

The total cost to the woodyard for handling 1 cubic metre of pine is made up as follows:

The cost price

The transport cost for delivery

The labour cost

Overhead charges which amount to 2 * labour costs

You must calculate:

the total cost of handling 1 cubic metre of pine

the profit made on one cubic metre of pine

the profit margin on costs in selling 1 cubic metre of pine

Create a spreadsheet which clearly indicates all of this information.

2.

Now extend your spreadsheet to include the following information and extend the calculations you set up for Pine to include these extra products.

	MERANTI	IMBUIA	OAK	TEAK
COST PRICE	1768.45	2098	2765.89	2564.78
MASS	634	845	924	834
HANDLING TIME	2.78	3.05	3.65	3.65
SELLING PRICE	2400	3575	4500	4200

3.

Show on your spreadsheet what your total costs, profit and profit margin would

be if you handled and sold 1 cubic metre of each type of wood.

4.

Create a bar graph showing the cost and selling price of each of the types of wood. Give this graph the name COSTS.

5.

Create a pie graph showing what portion of your total profit is made up by each different type of wood.

WHAT IF ANALYSIS:

The cost prices of all your wood have gone up to the following:

PINE	1479.45
MERANTI	2012.34
IMBUIA	2314.45
OAK	3000.12
TEAK	2777.12

Your market analyst has informed you that the most the current market will absorb on Meranti, Imbuia, Oak and Teak is a 6% markup. Pine will take considerably more because of the demand. What must your selling price of PINE be if your overall profit margin is not to fall below 40%?

APPENDIX K: MARKING SCHEME FOR THE ASSIGNMENT

PINE ONLY	USING CONSTANT DATA	1
	DATA CORRECT OVERALL DATA ENTRY	1
	TRANSPORT COSTS	1
	LABOUR COSTS	1
	OVERHEADS COSTS	1
	HANDLING COSTS	1
	PROFIT	1
	PROFIT MARGIN	1
THE REST	DATA ENTRY	1
	TRANSPORT	1
	LABORATORY	1
	OVERHEADS	1
	HANDLING	1
	PROFIT	1
	PROFIT MARGIN	1
TOTAL	COSTS	1
	PROFIT	1
	PROFIT MARGIN	1
	FORMATTING TO SENSIBLE NUMBER OF SIGNIFICANT FIGURES	1
	SENSIBLE COLUMN WIDTH	1
GRAPHS	CORRECT TYPE	1
	CORRECT X SERIES ALLOCATION	1
	CORRECT Y SERIES ALLOCATION	1
	NAMING OF GRAPHS	1
WHAT IF ANALYSIS	COSTS DYNAMICALLY LINKED TO PROFIT MARGIN	1
	CORRECT PERCENTAGE INCREASES	1
	SELLING PRICE DYNAMICALLY LINKED TO PROFIT MARGIN	1
	LABOUR COSTS DYNAMICALLY LINKED TO HOURLY WAGE	1
	TRANSPORT COSTS DYNAMICALLY LINKED TO COST/KM	1
	CORRECT SELLING PRICE FOR PINE WITHIN THE GIVEN CONSTRAINTS	1
TOTAL		30

APPENDIX L: A BRIEF OVERVIEW OF THE SPREADSHEETS USED IN THE ASSESSMENT OF THE INSTRUMENT

In order to conduct the various reliability and validation studies, a set of spreadsheets was created. These spreadsheets are generic in that when a new test is written using the computer based testing system, the new results are imported directly from the testing system into the spreadsheet system. The lecturer need only create these templates once.

A system of linked spreadsheets was used rather than one large worksheet in order to facilitate ease of maintenance. This system is diagrammatically represented below in Figure A.

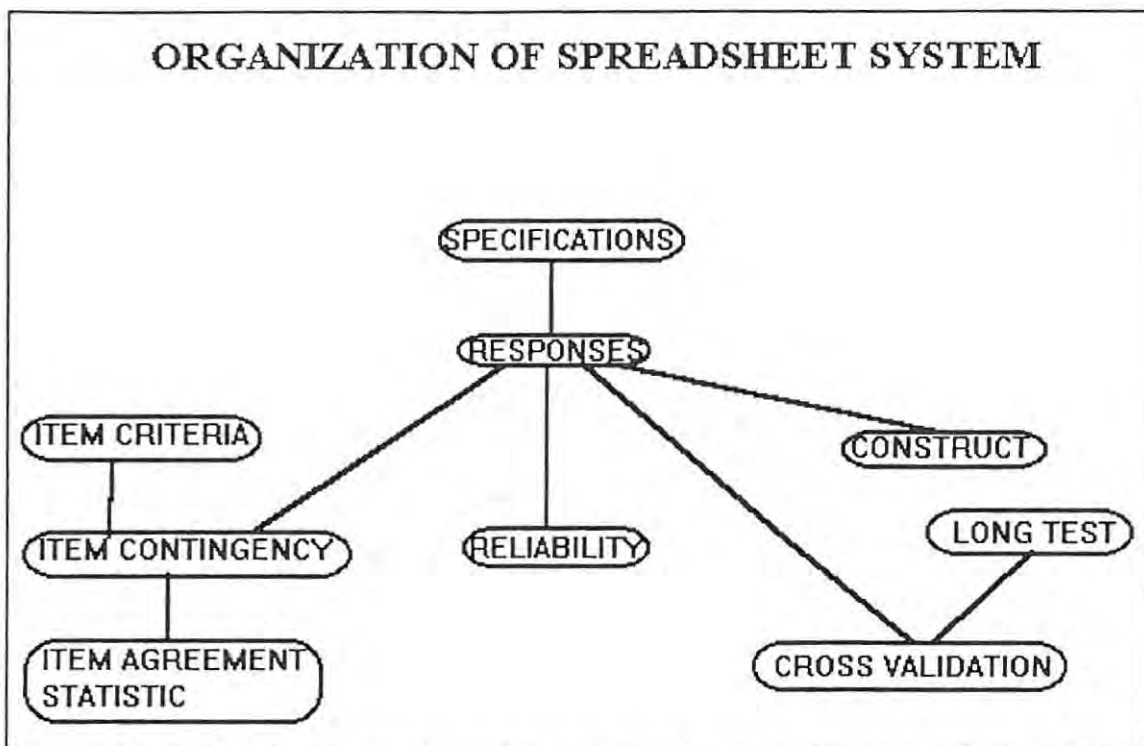


Figure A SPREADSHEET SYSTEM FOR THE ANALYSIS OF THE ASSESSMENT INSTRUMENT AND THE STUDENTS' RESPONSES.

Each of the blocks shown in the diagram represents a separate table. The lines connecting tables show that dynamic links exist between those tables in order to facilitate the integrity of the worksheets and ease of maintenance. A brief explanation of each table and its links is given below:

The specifications table is nothing other than the instrument specification.

The responses table is the table generated by the computer based testing system which contains the score every student obtained on each item. The cut-off score is obtained from the specifications table and used to determine whether or not each student is a master or not.

The reliability table is used in order to calculate the agreement and kappa coefficients using Subkoviak's approximation procedure. The variances for each item are obtained from the responses table as well as the variance of the raw total score for the entire respondent group. The

tables shown in APPENDIX M are incorporated into this worksheet and used as lookup tables to determine the reliability indices once z and KR20 have been calculated.

The construct table is used to perform the Guttman scalogram analysis. The contingency patterns are keyed in and used as criteria ranges by the database counting function to scan the responses table which is also used to calculate the mastery on each objective for each student by referring to mastery levels for each objective in the specifications table. The result is a count of the number of students for each contingency pattern whose objective mastery sets match that pattern.

The long test table contains the students 'project' results.

The cross validation table obtains the students computer based score from the responses table as well as their project mark from the long test table. This worksheet is then used to execute the cross validation process in order to assess the predictive validity of the instrument.

The item contingency table is used to generate the contingency table for each item needed in order to calculate the agreement statistic. It obtains the criteria to be used by a database count statement from the item criteria table in order to scan the responses table to perform the count.

The item agreement statistic table is used to determine the required statistic for each item based upon the item contingency table's information.

APPENDIX M: LOOKUP TABLE FOR RELIABILITY INDICES

Agreement Coefficient

Approximate values of the agreement coefficient									
	r								
z	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
0.00	0.53	0.56	0.60	0.63	0.67	0.70	0.75	0.80	0.86
0.10	0.53	0.57	0.60	0.63	0.67	0.71	0.75	0.80	0.86
0.20	0.54	0.57	0.61	0.64	0.67	0.71	0.75	0.80	0.86
0.30	0.56	0.59	0.62	0.65	0.68	0.72	0.76	0.80	0.86
0.40	0.58	0.60	0.63	0.66	0.69	0.73	0.77	0.81	0.87
0.50	0.60	0.62	0.65	0.68	0.71	0.74	0.78	0.82	0.87
0.60	0.62	0.65	0.67	0.70	0.73	0.76	0.79	0.83	0.88
0.70	0.65	0.67	0.70	0.72	0.75	0.77	0.80	0.84	0.89
0.80	0.68	0.70	0.72	0.74	0.77	0.79	0.82	0.85	0.90
0.90	0.71	0.73	0.75	0.77	0.79	0.81	0.84	0.87	0.90
1.00	0.75	0.76	0.77	0.77	0.81	0.83	0.85	0.88	0.91
1.10	0.78	0.79	0.80	0.81	0.83	0.85	0.87	0.89	0.92
1.20	0.80	0.81	0.82	0.84	0.85	0.86	0.88	0.90	0.93
1.30	0.83	0.84	0.85	0.86	0.87	0.88	0.90	0.91	0.94
1.40	0.86	0.86	0.87	0.88	0.89	0.90	0.91	0.93	0.95
1.50	0.88	0.88	0.89	0.90	0.90	0.91	0.92	0.94	0.95
1.60	0.90	0.90	0.91	0.91	0.92	0.93	0.93	0.95	0.96
1.70	0.92	0.92	0.92	0.93	0.93	0.94	0.95	0.95	0.97
1.80	0.93	0.93	0.94	0.94	0.94	0.95	0.95	0.96	0.97
1.90	0.95	0.95	0.95	0.95	0.95	0.96	0.96	0.97	0.98
2.00	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.98

Kappa coefficient

Approximate values of the Kappa coefficient									
z	r								
	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
0.00	0.06	0.13	0.19	0.26	0.33	0.41	0.49	0.59	0.71
0.10	0.06	0.13	0.19	0.26	0.33	0.41	0.49	0.59	0.71
0.20	0.06	0.13	0.19	0.26	0.33	0.41	0.49	0.59	0.71
0.30	0.06	0.12	0.19	0.26	0.33	0.40	0.49	0.59	0.71
0.40	0.06	0.12	0.19	0.25	0.32	0.40	0.48	0.58	0.71
0.50	0.06	0.12	0.18	0.25	0.32	0.40	0.48	0.58	0.70
0.60	0.06	0.12	0.18	0.24	0.31	0.39	0.47	0.57	0.70
0.70	0.05	0.11	0.17	0.24	0.31	0.38	0.47	0.57	0.70
0.80	0.05	0.11	0.17	0.23	0.30	0.37	0.46	0.56	0.69
0.90	0.05	0.10	0.16	0.22	0.29	0.36	0.45	0.55	0.68
1.00	0.05	0.10	0.15	0.21	0.28	0.35	0.44	0.54	0.68
1.10	0.04	0.09	0.14	0.20	0.27	0.34	0.43	0.53	0.67
1.20	0.04	0.08	0.14	0.19	0.26	0.33	0.42	0.52	0.66
1.30	0.04	0.08	0.13	0.18	0.25	0.32	0.41	0.51	0.65
1.40	0.03	0.07	0.12	0.17	0.23	0.31	0.39	0.50	0.64
1.50	0.03	0.07	0.11	0.16	0.22	0.29	0.38	0.49	0.63
1.60	0.03	0.06	0.10	0.15	0.21	0.28	0.37	0.47	0.62
1.70	0.02	0.05	0.09	0.14	0.20	0.27	0.35	0.46	0.61
1.80	0.02	0.05	0.08	0.13	0.18	0.25	0.34	0.45	0.60
1.90	0.02	0.04	0.08	0.12	0.17	0.24	0.32	0.43	0.59
2.00	0.02	0.04	0.07	0.11	0.16	0.22	0.31	0.42	0.58