THE SIMPLE SYSTEM — A NOVEL APPROACH TO TEACHING

SELF-INSTRUCTIONAL PROGRAMMED-LEARNING USING MICROFICHE

R.J. TODD,
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Department of Further Education
South Australia

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SUMMARY

This report summarises research carried out into the use of the microfiche as a medium for self-instructional programmed-learning during 1974 and 1975, and describes in detail a more intensive investigation carried out during 1976. In 1975 and 1976, this research was supported by grants from the Education Research and Development Committee. The novel relatively inexpensive, easy to use method of programmed-learning developed, has been dubbed the SIMPLE System, an appropriate acronym derived from Self-Instructional Microfiche Programmed-Learning.

In 1976, some 200 post-secondary students and some 230 junior secondary students participated as experimental subjects in this research. With the latter, the measured performances of groups of subjects respectively taught a mathematics topic by conventional didactic teaching, by a self-paced programme presented on microfiche and by precisely the same programme presented in booklet form, were statistically compared.

Similar investigations were carried out with the post-secondary students but in this case, when the group numbers were sufficiently large to justify it, the performances of students working in small groups using programmes presented in booklet and microfiche forms were also investigated. A number of different groups of post-secondary students participated in the project, ranging from the educationally disadvantaged to more able students undertaking para-professional studies. Similarly, the topics ranged from simple to more abstract mathematical topics, and included some science-engineering topics.

The statistical procedures employed include analyses of covariance and multiple regression analyses, and the results of these analyses show
that when the performances of the experimental groups are compared, overall there were no statistically significant differences between the effectiveness of the teaching methods used. However, many of the self-paced subjects were able to complete their studies in substantially reduced times.

In addition, the report contains analyses of survey data, obtained from students giving their views on programmed-learning presented in both booklet and microfiche form, compared with didactic teaching. These analyses show that the majority of the students who participated favour the use of self-paced programmes presented on microfiche to supplement or complement conventional teaching. Indeed, with most groups, the microfiche ranks about equally with the latter as the preferred teaching method, providing an academic tutor is available to answer questions. Conversely, the booklet ranked a poor third preference, even when an academic tutor was suggested. It is shown elsewhere in the report that compared with the booklet and other media, the microfiche costs less and has many other advantages.

The opinions of the 19 teachers and lecturers who took part were also analysed. The results show that they saw self-paced programmes on microfiche as a means of supplementing or complementing conventional lessons rather than as a complete alternative to them. However, there were few criticisms of the method itself.

It is concluded that the findings of this research indicate that self-instructional programmed-learning using microfiche is a promising complement, supplement or alternative to conventional teaching. As such it may have a wide range of applications, for both internal and external students in many levels of education.

The report also reviews some of the educational and other theories relevant to programmed-learning. Further, both the means of producing self-instructional programmes in booklet and microfiche forms, the experimental techniques and the statistical analyses used are described in some detail. As a result, the authors hope that this report will prove of value to the broad cross-section of persons interested in the processes of learning and innovation in teaching, especially teachers, educational technologists, researchers, resource-centre managers and librarians.

R.J. Todd,
E.R. Cawthron.
Self-paced learning, as the name implies, means that people enrolled in TAFE courses should have the opportunity to proceed at their own pace, having regard to their personal capabilities and their other commitments. The concept is particularly applicable to the TAFE situation because of the wide range of courses that are offered, because of the wide spectrum of capabilities of people within the system, and because the majority of students study on a part-time basis which necessitates the provision of a variety of study options. The ACOTAFE Reports stressed the role that TAFE must play in the application of the concept of recurrent education. The Commission is particularly concerned about the situation of people returning to education after what might have been a substantial absence. Such people will normally need time to recustom themselves to a study situation and therefore should not be required to proceed at a pace suitable to those with more recent experience in the learning situation.

If self-paced learning arrangements are to succeed, certain organisational changes will be required in the TAFE system. More importantly, however, many teachers will be required to rethink their approach to teaching and reorient their courses so that more use is made of the total range of learning resources including college libraries. State TAFE authorities are already moving in this direction but the Commission is convinced of the need for further development of self-paced learning techniques.

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DEDICATION

To our wives for their patience and understanding.
THE RESEARCH TEAMS

1976

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Principal, Kilkenny College of Further Education.

E.R. Cawthron, Research Officer,
employed full-time during 1976, under a grant from the
Education Research and Development Committee.

J.A. Gajewski, Illustrating Assistant,
employed part-time during 1976, under a grant from the
Education Research and Development Committee.

C.A. Vickery, Office Assistant (Typist),
employed for 2 months during 1977, under a grant from the
Education Research and Development Committee to type part
of this report.

1975

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Principal, Kilkenny College of Further Education.

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Australian Advisory Committee on Research and Development
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in Education.

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Australian Advisory Committee on Research and Development
in Education.

In addition, Miss J. Marshall, Mr. Todd's secretary, has throughout the
whole of this research project played the vital role of typing and
preparing all the earlier reports and papers associated with this research,
and much of this report.
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In envelopes attached to inside of rear cover
1. **INTRODUCTION**

During the past decade there has been a growing interest in the use of audio-visual materials in education. There are several reasons for this trend. Certainly, there is the hope that the quality of teaching and learning will be improved when the more traditional didactic method is supplemented or complemented by the use of these materials. Secondly, there is the hope that the escalating costs of the labour-intensive traditional means of teaching may be reduced, or at least contained, by the use of audio-visual materials. Thirdly, in most sectors of education, owing to social changes, many students simply will not accept the discipline of continual didactic teaching, and many teachers are not prepared to subject them to it, but insist on a greater variety of teaching methodology and a greater personal freedom and choice in their educational programmes. And no doubt there are many other manifest and latent reasons for the trend, which, at least until comparatively recently, has been most obvious in those primary and secondary schools which utilize the open-space unit approach to education, and in which the conventional libraries have been replaced by library-resource centres.

While undoubtedly influenced by this trend, the Chief Investigator was consciously initially most concerned with a need to improve the access of potential students to Further Education.* However, the subsequent research has indicated that the method of self-instructional programmed-learning using microfiche described in this report should find applications in most levels of education. Favourable results have already been obtained with experimental groups of secondary and post-secondary students.

Referring to the access of students to Further Education, Colleges of Further Education have for many years offered introductory courses that attempt to bridge the gaps between the entry requirements of those courses for which certain educational pre-requisites are important, and the educational attainments of those students who lack this knowledge. However, because the students entering Colleges of Further Education have educational backgrounds that are more diverse than is normally the case with those entering the Universities or Colleges of Advanced Education, the needs of the students for bridging-courses range from the general to the

* The Chief Investigator first described the method of self-instructional programmed-learning using microfiche in April, 1974 (1).
1. **INTRODUCTION Contd.**

specific. For example, these students range from the school leaver with a poor academic record to the able adult, who wishes to commence a course in order to retrain for another career.

As a result of the diverse backgrounds of these students, it is difficult to design bridging-courses to be undertaken in a conventional teaching situation, that meet their particular individual needs and, inevitably, such courses are a compromise and some students are discouraged. This is, of course, but one of the many complex reasons for the high withdrawal and failure rates that are commonly encountered among such students, but in this respect, self-instructional programmed-learning courses appear to offer many advantages. For these courses may enable each student to study topics that meet his specific needs, for example, mathematics or physics and other subjects, which he may study at his own pace, and at a time that is convenient to him.* In addition, it is likely that self-instructional programmed-learning courses will appeal to some of the group of students, who either for personal reasons, or owing to their employment commitments are unwilling or unable to commence their post-secondary studies by regular attendance at conventional classes.

Ideally, the programmes should be designed as branching programmes which enable the able or experienced student to by-pass information with which he is already familiar and to proceed rapidly through the programme, while the less able or less experienced student is directed through those parts of the programme that he needs.** In this way, the needs of each individual student may be best met. In this report it is demonstrated that as a medium for self-instructional programmed-learning, the microfiche has many practical advantages. Further, it is suggested that owing to the method of using the microfiche in which the student must take positive action in order to work through the programme, he is more likely to learn than with other methods with which he can play a more passive role. The method of using the microfiche as a medium for self-instructional programmed-learning described in this report, is believed to be essentially novel.***

* Other educationalists have referred to the value of self-paced courses in this respect. (2).

** Skip-linear programmes offer, to a more limited extent, similar advantages but are less flexible.

*** Microfiche has been used as an instructional medium since about 1969 (3)(4)(5)(6)(7) but only as a support material. Its distinctive properties for individualization of instruction was recognised about 1971 (8). The general advantages of microfiche compared with slides are also discussed by Burch (9). The particular advantages for branched programmes was realised first by the Chief Investigator in 1974 (10).
1. INTRODUCTION Contd.

Because the system of self-instructional programmed-learning using microfiche is a relatively inexpensive, low-technology, easy to use and low-maintenance system, it has been dubbed the 'SIMPLE SYSTEM' by the Chief Investigator. This acronym is obtained by suitably arranging the title of this means of self-paced learning to Self-Instructional Microfiche Programmed-Learning, and by selecting appropriate letters.

In the course of the research described in this report, the performances of numbers of students, working as individuals and in small groups have been compared by means of statistical analyses, when taught by conventional didactic teaching, by self-instructional programmes presented on microfiche, and by precisely the same programmes presented in booklet form. In addition, the opinions of the students who participated in this investigation into the use of the SIMPLE SYSTEM, with or without a tutor, as an alternative to conventional teaching have also been statistically analysed and related to their personal characteristics. So far, library searches have found no record of any previous similar empirical research.*

Owing to a high priority of need to provide self-instructional programmes for students requiring assistance in introductory mathematics, the pilot-investigation which was carried out in 1975, was limited to this area of study. However, during 1976, the performances of students have been investigated with a number of mathematical topics ranging from the simple to the relatively conceptually complex. Further, the performances of students with two physics/engineering topics have been analysed. In addition, some self-paced programmes on non-mathematics-physics topics have been developed which the researchers hope to investigate later.

The results of the investigation to date clearly indicate that under given conditions the SIMPLE SYSTEM can be an effective means of teaching, which may have broad applications. Consequently, it is hoped that this concept of programmed-instruction will be adopted in many levels of education. These will include external studies courses, for owing to the low-bulk of the microfiche, it is particularly suitable for distribution by mail.

* However, WACHTEL, L.W., (1970) has compared the performances of two small groups of students taught by a programme on microfiche adapted from a one-hour lecture on the slide rule. One group had received prior instruction and the other had not. Perhaps, not surprisingly, the former group performed better. He did not compare the performances of students taught by the programme on microfiche with that of students taught by other methods. (11).
2. RESEARCH PROGRAMME

The research programme was designed as a two-year study, a pilot investigation in 1975 and a detailed investigation in 1976. However, in an effort to make self-instructional programmed-learning courses using microfiche available to students as soon as possible, an effort was made in the pilot investigation to investigate, at least to some extent, each aspect of the research programme shown below.

.1 Research Programme, 1975

The research programme of the pilot investigation carried out in 1975 is shown below. This research was aided by a grant of $17,311 from the Australian Advisory Committee on Research and Development in Education.

a) Research and determine the best means of presenting programmed-learning courses on microfiche.

b) Determine the priorities of need for given topics to be taught by this method.

c) As a pilot study, develop a number of programmes, high in priority, for validation, evaluation and comparison with other methods of teaching.

d) Carry out the requisite validation and evaluation of the pilot programmes.

e) At the same time to provide a consultancy service to advise other teaching staff on such programmes using microfiche, that they may wish to develop, to meet the urgent needs of students.

f) To make recommendations on the method and staffing necessary to establish full-scale production of self-instructional programmed-learning courses using microfiche.

The results of this pilot investigation are summarised in Section 6, and are described in detail elsewhere. (12). The results of this investigation were considered to be sufficiently favourable to justify further research into self-instructional programmed-learning using microfiche. The researchers are therefore most grateful that the Australian Advisory Committee on Research and Development in Education, now the Education Research and Development Committee, awarded the Chief Investigator another grant of $20,000 to enable this research to be continued during 1976.
2.2 Research Programme, 1976

The research programme of the detailed investigation carried out in 1976 is shown below.

a) Refine the methods developed in 1975, for producing programmed-learning courses on microfiche.

b) Determine the priorities of need for given topics to be taught by this method.

c) Develop a number of programmes, in as wide a variety of subjects as possible, for validation, evaluation and comparison with conventional classroom teaching, and for comparison with the same programmes presented in booklet form, with both individuals and groups of students.

d) Carry out the requisite validation and evaluation of these programmes.

e) Consider the cost effectiveness of self-instructional programmed-learning using microfiche in comparison with other methods of teaching and programmed-instruction.

f) At the same time provide a consultancy service to advise other teaching staff on such programmes using microfiche, that they may wish to develop, to meet the urgent needs of students.

g) Finally, to make recommendations on the method and staffing structure to establish full-scale production of self-instructional programmed-learning using microfiche.

During 1976 the majority of the listed aspects of the research were thoroughly investigated and all were considered. In particular, in 1976 the researchers were able to investigate the viability of self-instructional programmed-learning using microfiche with a number of topics, with a broad range of students, ranging from first-year high-school students to mature age students undertaking vocational educational programmes. A paper presented at the S.A.M. '76 Conference dated 15th July, 1976, served as an interim report on this work (13). It should be noted that the reference to the use of the materials by groups of students, sprang from the comments of some of the students who participated in the pilot investigation in 1975, and who considered that their learning would be enhanced by working in small groups using the programmes.
3. THE USE OF MICROFICHE FOR PROGRAMMED-LEARNING (THE SIMPLE SYSTEM)

Having determined a need to provide self-instructional programmed-learning courses for students seeking access to Colleges of Further Education, and as a means to supplement or complement conventional teaching in these Colleges, the schools and elsewhere, it was necessary to select a medium for the programmed-learning courses. Today, one sees the choice of a wide range of educational media, for example, educational television, audio tapes, film-loops and photographic slides, plus, of course, the printed text. Each of these media or combination of these media may be used to good advantage in given applications, and are already in use at Kilkenny College of Further Education and elsewhere in the South Australian Department of Further Education.

The choice of the educational medium, like education itself, is not an exact science, but after due consideration of the self-instructional programmed-learning courses planned, it was decided that the microfiche has several advantages that make it a very suitable medium for these courses.

.1 Advantages of the Microfiche

a) Of prime importance in the choice of a medium for self-instructional programmed-learning, is the need to use a medium which is suitable for branching programmes, so that the experienced student may by-pass information in the programme with which he is already familiar, while the less able or less experienced student is directed step by step through the whole programme. This results in a considerable saving in time for the experienced or able student and provides an opportunity for the slow-learner to master his course work. In addition, branching programmes are more

* Alternatively, with less flexibility, skip-linear programmes may be used.
** ANDERSON, H.O., writes 'One of the particularly useful roles of programmed-instruction is to supplement classroom presentations. For the slow learner, it represents an aid to learning which will enable him to catch up with the average pupils and even overtake them. And he can do this in his own time without requiring tutorial assistance from the teacher. Multiply this situation by the ten or twenty slowest learners a teacher has in all his classes and he will have a great deal of time freed for research or professional reading, and his pupils will not have suffered.'

For the rapid learner, supplementary programmed materials provide a pushing-out of horizons. Here is one more method of supplying opportunities beyond the classroom routine to the better students who might otherwise sink into slovenly study habits for lack of challenging tasks.' (14).
3.1 Advantages of the Microfiche Contd.

likely to offer the challenges considered to be essential for achievement motivated students or the high success rate sought by failure-threatened students, see Section 3.3.9, than simple linear programmes. As is described in Section 3.2, the microfiche is a very convenient medium for branching or linear programmes.

b) Secondly, the availability of inexpensive multiple copies is essential so that multiple copies of each programme may be made available in College resource centres, so that any student may at any convenient time when the resource centre is open, use the programme of his choice in a study carrel equipped with a microfiche viewer. In the case of the microfiche not only are copies of the programmes inexpensive but they may be reproduced, on demand, in the vicinity of the charging desk of the library-resource centre.

c) Thirdly, the microfiche results in an enormous saving of storage space compared with more conventional materials.* This saving in space and the ease of filing and retrieval of the microfiche, ready for use, is of considerable importance in a resource centre. In addition, the relatively small bulk of the microfiche makes it eminently suitable for distribution by mail.

d) Fourthly, the ease of producing microfiche materials and the low cost of reproduction also makes provision for the rapid amendment or updating of the programmes, at relatively low cost compared with other materials.

e) Fifthly, the low-cost of microfiche duplicates and their ease of storage and retrieval, makes it feasible to provide the same self-instructional programmes in a range of ethnic languages so that migrants from non-English speaking countries are not disadvantaged. Similarly, the same advantages made it possible in practice to provide programmes on given topics but with different conceptual approaches so that for example, in the terms of the developmental psychologist Piaget, concrete and formal thinkers may be accommodated, see Section 3.3.6.

f) Sixthly, the ready availability of such programmes will enable the student to use them as a means of self-diagnosis before entering or while undertaking a course of study.

* Thomas has discussed the logic of placing colour slides in microfiche rather than the conventional format (15). See also the article by Lee who converted charts, graphs, texts, etc. to fiche format (16).
3.1 Advantages of the Microfiche Contd.

9) Sevently, the programmes may be used by students, with or without a teacher, as an alternative to conventional lecture or tutorial sessions. In these and other applications, the programmes need not be self-contained but may refer the students to other reference materials while they work through the programmes, thus providing diverse but structured learning experiences. Similarly, although the programmes described in this report require no other supporting materials, there is no reason why self-instructional programmes using microfiche should not be complemented by other media, e.g. a sound commentary on a magnetic tape, when the need arises.* Indeed, already a sophisticated computer-based system exists in which sound commentaries are recorded directly on the fiche used as the medium for reference materials. (17).

(h) Eighthly, the students need not of necessity work in isolation, for owing to the relatively large screens of available microfiche viewers that are suitable for self-instructional programmed-learning using microfiche, this form of programmed-learning is suitable for use by small groups, who may be joined when necessary by an academic tutor. Ideally, when self-instructional programmed-learning is used in College library-resource centres or elsewhere, teaching staff should be available, on call, to assist any students who need assistance with their programmed-learning courses.**

(i) Ninthly, with the use of the microfiche viewer described, the student is directed to select a frame of the microfiche, according to his answer to the previous frame and cannot sit back and play a passive role. Further, it is hoped that he will not find it easy to simply skim through the programme. As a result, it is suggested that he is more likely to learn than with alternative methods which allow him to play a more passive role. See Section 3.3.10.

* Robinson writes "There is no longer any real doubt about the value of multimedia systems for students who come from culturally different and academically deprived backgrounds... Learners who are considered high risks usually come with a background that has prepared them to deal more successfully with concrete and visual objects. They, too, are a part of the television or visual generation. Students from an academically deprived background need more remedial instruction than most of the other learners." (18). See also Burris and George (19).

** In two previous short publications the Chief Investigator has pointed to the desirability of the employment of academic tutors in resource centres. (20), (21). The possible role of the librarian as an academic tutor is also briefly discussed by Cawthon (22).
3.1 Advantages of the Microfiche Contd.
j) Tenthly, facilities for the reproduction of colour microfiche are becoming available in Australia. With these, at greater cost, colour microfiche may be used as an alternative to monochrome microfiche for programmes for which colour is important, e.g. in geography or arts programmes.* Owing to the relative inaccessibility of colour microfiche reproduction in Australia at the time of the research described in this report, the research described primarily utilized monochrome microfiche. However, it is anticipated that the cost of colour microfiche copies will be considerably lower than alternative materials, e.g. colour slides.

k) Finally, the use of the microfiche as an alternative to printed materials has been advocated on the ecological and pragmatic grounds of the rapid destruction of the world's forests, associated with the production of paper.** However, this argument may be suspect, as it seems unlikely that the photographic materials associated with the production of microfiche are inexhaustible.

Since this research into self-instructional programmed-learning using microfiche commenced in 1974, microforms and in particular the microfiche, have revolutionised much of data storage in industry and commerce, particularly in North America. This trend is already making its impact on the everyday life of the lay-person in Australia, for customers of the local service station, Medibank and elsewhere can hardly fail to notice the use of microform materials. For example, in many automotive service stations, the service manager no longer has to spend hours or days updating or replacing the sheets of a printed tome of car parts but instead receives through the post, from the manufacturer, sets of low-cost microfiche either for the latest car model or to replace previous obsolete sets.

For simple systems, manual retrieval of a particular microform and a given 'page' on it, is both convenient and simple. For example,

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* For a discussion of colour microfiche in medical education see abstract of article "The Use of Colour Microfiche in Medical School Instruction" by Walters, R.F. and Renner, W.E. in Microfiche Newsletter (23) and the article "Colour Miniatures for Medical Education" by Lewis, Elizabeth M. (24). The latter article discusses the advantages of microfiche vis-a-vis slides.

** However, Yerke's (1974) sees the paper shortage leading to the greater use of micrographic storage of reference materials but does not believe that original information will be greatly produced in this form. (25).
3.1 Advantages of the Microfiche Contd.

Microfiche may be stored and retrieved in much the same way as library catalogue cards, the requisite 'page' of the selected fiche being displayed on a microfiche reader. However, for larger systems, electronic retrieval systems are available at relatively low-cost, in the region of $6,000, which enable any one of some hundreds of thousands of 'pages' to be retrieved in a few seconds.

It is, therefore, little wonder that microform materials, and in particular the microfiche, are superseding more conventional materials in library-resource centres, primarily in an attempt to reduce cost and also alleviate the crisis of a lack of shelf space brought about by the burgeoning demands for resource materials of students and staff (26). Already there are some seven companies in Australia publishing in microform as an alternative to the conventional text, and in the U.S.A. there are said to be 220 publishers in the field of educational micropublishing (27). Perhaps of even greater relevance to this research, is the fact that students undertaking the part-time law degree at Newcastle-upon-Tyne Polytechnic are now successfully being supplied with reference materials on microfiche instead of photocopies, at a saving quoted as £4 per fiche (28). In this example, the students are loaned microfiche readers, two students sharing each reader. For recent discussions on the use of microfiche in educational settings, see The Times Higher Educational Supplement, 8.10.76 (29), and Fothergill, 1976 (30).

These recent developments have endorsed the conviction of the authors of this report that the microfiche has many advantages that make it a primary choice as the medium for self-instructional programmed-learning. Undoubtedly, in the near future most library-resource centres will be provided with microfiche readers, and will be equipped with, or have access to, the equipment necessary to produce microfiche. In most cases this equipment will initially be intended for the reproduction of more conventional materials and micropublications. However, in principle, there is no reason why considerable economies should be obtained by the use of the same equipment to produce and display self-instructional programmes using microfiche.

* It is reported that the research described in this report has indirectly influenced the provision of microfiche readers in every State school in South Australia. These readers will initially be provided for library catalogue purposes (31).
3.1 Advantages of the Microfiche Contd.

Providing such production facilities are available, the teachers or lecturers concerned may be intimately involved in the design of the programmes. This was the case with the research described in this report, in which Further Education and primary and secondary school teachers actively participated in both the programme design and in the investigations into their use. However, this approach may not be entirely possible in cases where programmes are designed and produced centrally and used throughout a large educational system.

2 Principle of Operation

Figure 3-1 shows a microfiche. Each of the 60 images of the microfiche shown in the illustration can represent a page of information and forms a frame of a self-instructional programme. The images are arranged in a grid pattern which enables any given image to be identified. Alternative formats of microfiche are also available with a greater number of images. Figure 3-2 shows a microfiche viewer equipped with an index card and an image locating pointer. Each numbered position on the index card represents an image on the microfiche, and by aligning the locating pointer with a chosen numbered position on the index card, the associated image may be selected by the student for display on the screen of the microfiche viewer. Figure 3-3 shows a microfiche viewer in use in a study carrel in a library-resource centre.

In the system of programmed-learning described in this report, each image of the microfiche represents a logical step in a self-instructional programme. In the programme design, the first image always gives the title of the programme and the second states any materials required by the student in order to work through the programme. The third image, to use a simplified example, might state a theorem, the fourth might give a worked example and the fifth image might pose a problem for the student to work out himself. In each case, the student is directed from one frame of the programme to the next by the direction 'GO TO FRAME X'.

In this way the student progresses through a series of frames forming a linear programme until he is presented with a problem and required to work out the answer before proceeding. In an effort to ensure
INTRODUCING ALGEBRAIC EQUATIONS

FIGURE 3-1
A MICROFICHE
FIGURE 3-2  MICROFICHE VIEWER WITH INDEX CARD AND IMAGE LOCATING POINTER
3.2 Principle of Operation Contd.

that the student is actively involved in the learning process and to reduce the temptation to the student to take a quick look at the answer, a deliberate spatial discontinuity is normally introduced at such points in the programme. Therefore, in the given simplified example, the fifth image, which poses the problem, does not direct the student to the sixth image but to a more remote image, say image 50. Further, image 50 is likely to present the student with a number of answers to the problem, against each of which is a direction to proceed to a particular image. Then if he selects the correct answer, the student is directed to the next aspect of the programme to be mastered. Conversely, if an incorrect answer is selected, he is directed to a branch of the branching programme, which, for example, by means of a number of frames re-states the theorem and gives additional worked examples before the same or another problem is posed by the programme.

In this way the student is, in effect, directed through a maze, in which it is not easy for him to by-pass any part of the programme, unless owing to his choice of a correct answer, the programme directs him to do so. In this way, ideally, each student is directed along those branches of the programme that best meet his individual needs. Furthermore, it is hoped, see Section 3.3.10, that owing to the design of the programmes the students will not simply be passive recipients of information but will be actively engaged in the learning process. In addition, owing to the utilization of the image locating pointer, progress through the maze is subject to far less frustration than that involved in the turning of pages to and fro, when branching programmes are presented in book form.

Further, in an attempt to maintain and to improve the motivation of the weaker or failure-threatened students using the programmes, see Section 3.3.9, cartoons are used in the programmes, particularly either as rewards for those parts of the programmes successfully completed, or to reduce the sense of failure when a part of a programme is unsuccessfully completed. In this respect, it should be remembered that many of the students taking bridging-courses are educationally disadvantaged, and as a result are more accustomed to failure than success in academic pursuits. For the same reason, it is considered important that for these students, each programme be limited to a relatively easily assimilated topic, the completion of which will give the student a sense of accomplishment, rather
3.2 Principle of Operation Contd.

than providing more extensive or complex subject matter, with a greater attendant risk of failure.

In the case of programmes which comprise in effect only a list of factual content, it may not be possible to provide branches of differing complexity. Nevertheless, it may still be of value to include spatial jumps in the programmes to ensure the active participation of certain students.

Alternatively, it is not necessary for the programmes to include all the information to be learnt by the student. The spatial jump need not be restricted to movement from one part of the fiche to another but may instead be to other reference material. For example, the student may be directed to read a prescribed section of a given reference text, or to view a given film or video programme before returning to the self-instructional microfiche programme. In this way diverse but structured lessons or tutorials may be designed to suit the full range of intellectual abilities of students.

3.3 Theoretical Considerations in Programmed-Learning

Many educational psychologists believe that the best learning environment is one in which five factors are operative (32):

a) The learner is cognitively active.

b) The learner gets frequent aid and feedback on his performance.

c) Learning proceeds gradually from the less complex toward the more complex in an orderly fashion.

d) The learner is allowed to develop his own best pace of learning.

e) The teacher's strategies are constantly reappraised on the basis of an objective analysis of the learner's activity.

On this basis, some programmed-instruction designers believe that they can provide such an environment by presenting (33):

a) An ordered sequence of stimulus items,

b) to each of which a student responds in some specified way,

c) his responses being reinforced by immediate knowledge of results, so that he moves by small steps,

d) therefore making few errors and practising mostly correct responses,

e) from what he knows, by a process of successively closer approximation, what he is supposed to learn from the programme.

27
3.3 Theoretical Considerations in Programmed-Learning Contd.

This list is clearly related to some learning theories but is not sufficiently explicit in its reference to others to enable the programme designer to utilize the full potential of self-instructional programmed-learning. Therefore, some of the more relevant theoretical considerations are outlined below.

1. Skinner and Step-Wise Progression

The concept of a simple linear programme in which all learners progress steadily through the entire programme from frame to frame probably goes back to Skinner (34).

Each learner proceeds through a sequence of frames, each frame containing a small amount of the material to be learned and requiring an active response (answering a question) on the part of the student. After each response, the student immediately learns whether he is correct or not so that there is reinforcement and immediate feedback.

Skinner envisaged a programme as a linear progression of small steps so that the average student would find the questions reasonably easy and would make a minimum number of wrong responses.

In Section 3.3.9 "Achievement Motivation" it is suggested that learners high on achievement motivation are in fact more highly motivated when there is a moderate risk of failure. Also the simple linear design ignores the differences in development levels and conceptual knowledge of the students, see the subsequent sections on Piaget, Ausubel, Gagne, etc. However, these difficulties can be partly compensated for by further individualisation of the teaching method, e.g. by the use of branched or branching programmes. *

* Howe points out that a branching programme is more adaptive to the needs of a wider range of learners (35). Also that the basic or main sequence generally proceeds in larger steps than is common with linear sequences. He suggests that books are a particularly unsuitable medium for branching programmes because of the amount of page turning involved. He does not mention microfiche as a medium, probably because he is unfamiliar with it. As the authors stress elsewhere in this report, it is a particularly useful medium for such programmes. Also branching programmes involve the learner more actively than the linear version. They appear to have originated with Crowder. (36)(37).
3.3.2 Learning Hierarchies

When designing a self-instructional programme, and having determined the assumed starting knowledge or performance of the students and their required terminal behavioural performance upon completing the programme, there is evidence which shows that in the case of problem-solving topics, it is important to design each consecutive frame so that the task that it presents, is a logical sequential step in the presentation of the topic to be mastered. In this way, in the terms of R.M. Gagne, the programme is ordered in a learning hierarchy \* (38). However, there is also evidence which suggests that the sequence in the presentation of information in short programmes, or of lower-order principles or verbal knowledge is not so important. \#

White has discussed some problems associated with the design of learning hierarchies. One is the failure to distinguish between generalised skills and verbal knowledge and the other is the failure to define the elements of the hierarchy narrowly or completely enough (41). A learning hierarchy is concerned with the essential pre-requisites for learning a skill and there are no such pre-requisites for an element requiring only rote learning.

The concept of a learning hierarchy is particularly useful for mathematical and scientific programmes for a number of reasons:

\*

GAGNE, R.M., (1968). Referring to problem-solving tasks 'The skills have an ordered relation to each other, such that subordinate ones contribute positive transfer to superordinate ones'. (39).

\#

BROWN, J.L., (1970). "Niedermeyer..., quoting Evans, has written 'It is possible that with very short programs, scrambling the order of the items may make very little difference...'. The results of this study (Brown's) indicate that this may be the case, even for substantially longer programs, if the tasks being taught can be classified either as lower order principles or verbal knowledge. The opposite, however, seems to be the case when the tasks are the complex problem-solving behaviours that Gagne classifies as intellectual skills. It seems that here, even for bright and relatively mature learners, sequence can have an Important effect upon learning." (40).
3.3.2 Learning Hierarchies Contd.

(a) it forms a basic framework for programme design;
(b) it lends itself easily to both linear and branched designs so that not all students need be assumed to have the same pre-requisite skills;
(c) the student can work his way up the hierarchy at his own pace solving problems to test his conceptual understanding at each step. In addition, some questions can be included to assist the student in verbal recall of information;
(d) it is easy to revise or modify and prototype versions are readily discarded - especially cheap duplicate copies on microfiche;
(e) a "grand hierarchy" can be designed involving a number of programmes each one of which can be worked through separately in a pre-determined order, e.g. algebraic equations → simultaneous equations → differential equations or trigonometrical ratios → vectors → complex numbers, etc. (in practice the arrangement would be more pyramidal than linear). Hartley's conclusion that Gagne's hierarchical structure requirements are not confirmed was possibly due to the errors in design mentioned by White (42).

3 Ausubel and Meaningful Learning

Ausubel's theory also has some relevance to programme designers (43). He stressed that:

(a) new information will be learned if it can be fitted by the learner into an appropriate body of general concepts and principles;
(b) this body of general concepts and principles will depend upon the student's existing level of organised knowledge.

Thus a basic concept is that of advance organiser or conceptual framework to assimilate new information. The notion has some affinities with a Kuhnian paradigm and like the latter it has been modified to give more emphasis to concrete models (44)(45).
3.3.3 Ausubel and Meaningful Learning Contd.

It is problematic whether advance organisers assist in the learning of conceptual or intellectual skills and they may only apply to verbalised knowledge (46). Certainly, advance organisers can be written for verbalised knowledge elements in programmes, while the conceptual skills can be arranged in a Gagne type learning hierarchy.

The theories of Gagne and Ausubel are thus complementary. They both emphasise the pre-existing knowledge or skills possessed by the learner, and implicitly the need to regard learning as an individualised process rather than a process directed at whole classes assembled on the basis of chronological or mental age. The individual rather than the class is made the pivot of the learning process.

While the theories of Gagne and Ausubel are thus very pertinent to the design of programmes, whether branched or linear, they can be criticized as embracing a still rather simplistic model of the learner. In Section 3.3.6 the developmental psychology of Piaget will be discussed, which looks at the learner as a more active agent.

4 Skemp and Conceptual Schema

Skemp has advanced two principles for learning mathematics and mathematical-like topics which have special significance to the teacher.

(a) Concepts of a higher order than those which a person already has cannot be communicated to him by a definition, but only by arrangement for him to encounter a suitable collection of examples.

(b) Since in mathematics these examples are almost invariably other concepts it must first be ensured that these are already formed in the mind of the learner. (47).

These are very similar to Ausubel's main thesis, but the stress here is on examples not verbal definitions.

The programme designer must thus design suitable examples, whether on the main sequences or along the branches, to
3.3.4 Skemp and Conceptual Schema Contd.

communicate the concept with a minimum of "noise" or extraneous information. Moreover, the programmes must be designed in sequence so that a learner can backtrack to an earlier part of a programme, if necessary, when he finds that he is unable to apply a lower-order concept to a new situation, a result which we also noted follows from Gagne's theory.

Skemp describes a schema as a mental structure or a network of interrelated concepts which integrates existing knowledge and serves as a mental tool for the acquisition of new knowledge. However, a schema may have difficulty in accommodating to a novel situation, i.e. to a high degree of incongruity. A programme should be designed so that the learner retains a flexible outlook and is actively engaged in the learning process - the learning must be 'schematic' learning and not just memorizing the manipulations of symbols (48). Here the relationship to Piaget's theory is also evident, see Section 3.3.6.

5 The Value of Reinforcement

While there is little doubt that programmed-instruction is an effective means of teaching both in educational institutions and in industry (49), there is a controversy as to why it works. In particular, empirical research is inconclusive on the value of the provision of immediate feedback, that is an immediate knowledge of the correctness or otherwise of results. For it would appear that the extension of the work of Skinner from the operant conditioning of animals, in which animals repeat given tasks in order to gain rewards, is not a good analogy with students progressing through the steps of programmes. 

Hartley questions the value of immediate knowledge of results. Also, he comments that frequent feedback may be detrimental or superfluous unless the learner is not fatigued and has assimilated the necessary knowledge to correct his error. (50).
3.3.5 **The Value of Reinforcement Contd.**

Instead some researchers have argued that it is the additional information contained in the answers provided or alternatively, in the case of branching programmes, the additional information provided in the branches to which students are directed after a response, which is the important criterion (51). Nevertheless, research findings are reported which indicate that the greater the reinforcement, the fewer the errors made by the subjects, and the more the subjects liked the task. However, no similar improvement in long-term retention was obtained (52).

To conclude, despite the latter, and the lack of consensus on the mechanism of programmed learning, there appear to be sufficient results to justify immediate feedback. Nevertheless, in Section 3.3.9, it will be suggested that this is not a simple matter and that different feedback experiences are required by students with different characteristics. This same lack of consensus is no doubt equally relevant to the value of feedback in didactic teaching, where in the practical classroom situation, immediate feedback to each student is simply not possible.

6 **Developmental Psychology**

In the design of self-instructional programmes, as in conventional didactic teaching, it is necessary to present material in a form which is suitable for assimilation into the students' existing cognitive structures, or to which the structures may accommodate so that assimilation is possible. In the terms of the developmental psychologist Jean Piaget, the cognitive development of the normal child is divided into four successive stages, each of which is incorporated into its successor. These are the period of sensori-motor intelligence (0-2 years), the period of pre-operational thought (2-7 years), the period of concrete operations (7-11 years) and the period of formal operations (11 years onwards) (53)(54)(55). At each of these stages the child has different qualitative powers of handling problems and learning, and indeed the meaning he or she gives to stimuli (56).

However, it should be noted that the ages shown are nominal and that not every person will progress to the higher stages. For example, there is evidence that many of the students seeking
3.3.6 Developmental Psychology Contd.

Access to post-secondary studies are concrete thinkers, or in a transitional phase of cognitive development between the concrete and formal operations stage (57). These findings are supported by the work of other investigators elsewhere. * Research has shown that even among post-graduate university students, a large proportion of students who have not in all respects achieved the formal operations stage, may be encountered. **

Now according to Piaget's theory, intellectual development depends on the provision of suitable experiences which are appropriate to the student's stage of cognitive development. The student is then intrinsically motivated to respond, and learning is spontaneous. For cognitive structures perpetuate themselves by more functioning and no extrinsic motivation is needed (63)(64). Therefore, self-instructional programmed-learning offers a means of meeting this requirement, providing due allowance is made for the cognitive development of the student. Conversely, any excessively discrepant information or problem will be a 'non-question' to the child, and depending on the example, may lead to alarm and withdrawal. Certainly it will not convey the same meaning to the child as to the adult. (65).

* DALE, L.G., reports that at a mean age of 11-12 years, only approximately 10% of Melbourne children tested completely solved the combination of colourless chemicals problem, which is used to distinguish between concrete and formal thinkers, and this rose to only 25% at a mean age of 15 years (58). Similar findings, using different experimental procedures were obtained by McNALLY, D.W., (59) and ROWELL, J.A. and HOFFMANN, P.J. (60). Equally relevant are the findings of RICHARDSON, E., and KELLY, M.R., who found that of a sample of craft students entering further education in N.S.W., 6% failed a class inclusion test, 17% failed to conserve length and 48% could not conserve volume. Since the second-order operations required to conserve volume, are characteristic of the formal operations stage, on this criterion 48% of the students tested had not attained the formal operations stage of cognitive development. Excluding the 6% who failed the class-inclusion test, who may well have been pre-operational thinkers, the majority of the 48% were at various levels of development within the concrete operations stage. As a result, RICHARDSON and KELLY were not surprised to find that these students had some difficulty with engineering calculations. (61).

** ROWELL, J.A. and RENNÉ, V.J., report that in an experiment involving the manipulation of plasticine, 18% of the post-graduate Diploma in Education students tested failed to conserve volume. (62).
3.3.6 Developmental Psychology Contd.

Undoubtedly, self-instructional programmed-learning will find its greatest application with students in the latter stages of cognitive development, whether they be at primary school, secondary school, or undertaking post-secondary studies. For example, the concrete operations student is able to apply his intellect primarily to objects that are physically present and not to verbal hypotheses. However, towards the end of the concrete operations stage the student begins to extend his thought a little from actual situations to the consideration of possibilities, in order to seek explanations of anomalies in his findings. It is then that he enters a transitional phase between the concrete operations and formal operations stages.

The fundamental difference between the thinking of the student in the concrete operations stage and in the formal operations stage, is summed up by the phrase "the real versus the possible". The concrete thinker does not possess a unified cognitive logical system to systematically explore abstract relations independently of content. Hence, he cannot be greatly concerned with the non-present, or with hypothetical relationships. Whereas, in the formal operations stage, the formal thinker, having built upon the achievements of the concrete operations stage by an ontogenetic process, achieves these abilities. However, at all stages of development, the activity of the student in observing actual objects or situations is essential. The need is reduced in the formal operations stage but it is still an important foundation for thinking (67).

To give a practical illustration of the use of this theory, having taken note of the large proportion of concrete or transitional concrete-to-formal thinkers that are likely to make use of self-instructional programmed-learning using microfiche in

* FLAVELL, J.H., (1963). "The ... (concrete thinker) acts as though his primary task were to organise and order what is immediately present; the limited extrapolation of this organising and ordering to the not-there is something he will do where necessary, but this extrapolation is seen as a special-case activity". (66).
3.3.6 Developmental Psychology Contd.

bridging-courses, the investigators were aware of the need to make the content of the programmes for these particular students as 'concrete' as possible. In an attempt to do this, use was made of graphic illustrations and analogies wherever possible. For example, in a programme titled 'Introducing Algebraic Equations' used in this research, the algebraic equation is likened to a mechanical balance and the student is reminded that whatever he does to one side of the equation he must do to the other, in order to retain a balance.

7 Bruner and Information Processing

Thus far no mention has been made of the theories of Bruner. Having considered Piaget, however, mention may now be made of this well known advocate of 'guided discovery' methods.

According to Bruner, individuals possess three parallel systems or modes for processing information, each one representing a unique skill (68)(69), viz.

- enactive mode - learning through action
- iconic mode - learning through vision or hearing, etc.
- symbolic mode - learning through representation in words and language.

As with Piaget there is no passive copying of reality but rather a two-way interaction with the external world. However, unlike Piaget, for Bruner both the knowledge about the world and the skills or abilities used in gaining it initially, are external to the subject (70).

While one can agree in general with Bruner's scheme, too much emphasis on "discovery", guided or not, in programme design, can be detrimental unless the process is matched to the developmental level of the learner. Similar arguments may of course be applied to the work of Gagne.

Bruner's scheme would seem to argue for a multiplicity of teaching media to ensure that all information processing modes are utilised. Programmes should involve tactile, visual and auditory stimuli.

It follows that some interaction with the teacher as well as with other learners should be similarly beneficial.
3.3.8 Intrinsic Motivation

Reference has been made, see Section 3.3.6, to Piaget's approach to intrinsic motivation. Obviously, if programmes can be designed which intrinsically motivate the students to learn and progress, many of the problems of educators will be overcome.

Unfortunately, differing views and definitions of intrinsic motivation are held by rival schools of psychologists. Probably no one school of thought or conceptual model of the nature of intrinsic motivation is entirely complete, but several researchers consider the earlier drive theories to be inadequate in this respect and have moved to views not very dissimilar to those of Piaget.

For example, Hunt refers to limitations in Freud's psychoanalytic instinct theory and also Hull's basically similar drive-reduction theory with respect to intrinsic motivation (71). He cites Dashiell who as early as 1925 reported that rats would suffer electric shock for the privilege of exploring new territory (72). Similarly, he quotes Butler and Harlow (1957) who after noting that monkeys will learn complex discriminations when rewarded only by being allowed to look through a window concluded that 'monkeys - and presumably all other primates have a strong motive towards the visual exploration of their environment' (73). Hunt also cites the McGill studies of stimulus deprivation in which it was found that students who were well fed and free from pain, would not, despite financial inducement, remain 'quiescent' in a room with minimal stimulus variation. (74) (75).

These and other examples are clearly at odds with the notion of organisms only becoming active in order to reduce stimuli originating from pain, the homeostatic needs of hunger, thirst, etc. and from sex, or from stimuli previously associated with these stimuli.

Hunt refers to Helson's (1959) concept of adaptation level, from which moderate discrepancies, either positive or negative are attractive and pleasurable, but as the discrepancies become larger, they become less attractive and then repulsive (76). This appears similar to the optimum range for accommodation described earlier with reference to Piaget's theories.
3.3.8 *Intrinsic Motivation* Contd.

Hunt states that his definition of intrinsic motivation, namely, 'that motivation which is inherent in information processing and action' was suggested to him, after consideration of the work of Piaget and others, by the functioning of electronic computers and consideration of the kinds of processes that go on in the brain to enable animals and man to solve problems. Using the computer model, Hunt refers to 'incongruity' between the feedback of what is already stored in the individual's or organism's experience, and inputs (or lack of inputs) from the environment. For Hunt it is the degree of incongruity (arousal potential), having an optimum level for each individual, which leads to arousal and divides attraction and pleasure from repulsion and displeasure. It is thus the incongruity that is responsible for the organism's subsequent behaviour and provides the source of intrinsic motivation.

Therefore, on this basis, at least in the absence of external distractions or concerns, no bribery or coercion is required to persuade a student to learn. Instead, he will be intrinsically motivated by the provision of an appropriate learning environment.*

.9 *Achievement Motivation*

Broadly, achievement motivation may be defined as a generalised concern or competition of an individual with some standard of excellence, when the individual knows that his performance will be evaluated by himself or others (78). Research over the past 20 years has shown a tendency for subjects high in a need for achievement (as determined by the Thematic Aperception Test) to

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* Furth draws a distinction between "learning", as this term is commonly understood, and "development". He writes "parents and educators need not frantically look for contrived situations or rewards that will make intelligence grow. Intelligence grows from within. Thus the task becomes one of furthering and nourishing this growth by providing suitable opportunities, .... Learning, however is a different matter; it usually depends very much upon some reward or reason that lies outside the learning process". (77). In this report the authors primarily use 'learning' in the sense of developing cognitive structures to handle new intellectual tasks.
Achievement Motivation Contd.

prefer moderate risks (with approximately equal chances of success or failure), while those who are subjectively failure-threatened (as determined by the Test Anxiety score) either choose very low risks or very high risks. The latter is a gambling situation, where failure brings little embarrassment or shame. Therefore, it has been suggested that this knowledge is a step towards a theory of academic motivation (79).

Unfortunately, many investigations into achievement motivation have produced conflicting results. The majority of studies have been carried out with white middle-class American males as subjects, and like so many socio-psychological theories, the theory appears to have serious limitations when applied across the sexes, to men with strong affiliative motivation, and across cultural boundaries.

However, for those students to whom the theory may be applicable, the theory suggests that for failure-threatened subjects, a programme designed with minimum risk of failure is desirable (obviously, the educator cannot accept the alternative preference of the failure-threatened student, i.e. a high risk of failure). That is, these subjects need the encouragement of continued success. Conversely, the theory suggests that such a programme is not desirable for the achievement-motivated students who prefer the challenge or a moderate risk of failure.

Consequently, if the same self-instructional programmes are to be used across a given population of students, the authors consider that branching programmes are the best compromise. They could be designed to allow the achievement motivated students to seek moderate challenges, while, hopefully, the failure-threatened students, work through branches posing low risks, rather than gambling with the outcome.

For failure-threatened students, in particular, the authors believe that cartoons, e.g. WELL DONE, or BAD LUCK, possibly with a comic illustration, can play an important part. As stated in Section 3.3, the cartoons are used both as rewards.
3.3.9 Achievement Motivation Contd.

for those parts of the programmes successfully completed, and also to reduce the sense of failure when a part of a programme is not successfully completed.

An approach which might be closer to the ideal than the SIMPLE SYSTEM described in this report, but at considerably greater cost, would be to use a computer-aided self-instructional system. Then, provided each subject could be classified according to whether he was achievement-motivated or failure-threatened, and possibly incrementally within these categories, by keeping score of each subject's success-rate, the computer could adjust the difficulty of each task set to provide an optimum challenge to each student. This discussion will not be pursued further here. However, the able teacher in the conventional classroom or tutorial could and no doubt in many cases does, after assessing each student's characteristics, on an intuitive or theoretical basis, attempt to adjust the challenges set to each student.

10 Advantages of the SIMPLE-System

The educational theories summarised above should assist the programme designer with the selection of the format and content of self-instructional programmes. From the theories it is evident that no matter which medium is selected as the vehicle for a programme, the programme must be so designed to keep the student cognitively active, otherwise learning will not take place.

Putting aside the cost advantages of the microfiche, compared with self-instructional programmes presented on, for example, cine-film or video-tape, it is readily agreed that there are topics for which the microfiche cannot provide the same range of stimulation and depth of experience. In this respect, the microfiche should be seen as complementary to, rather than in competition with other media.

However, compared with cine-film, video-tape or, for that matter, slide-packs which are synchronised to an audio commentary, the SIMPLE System has the advantage that it is truly self-paced, in that the student selects one frame of the programme after the other, at his own rate.
3.3.10 **Advantages of the SIMPLE-System Contd.**

In addition, owing to the way the system is used, he cannot play a completely passive role, since he is required to take at least physical action in order to make any pretence of progress through the programme. Hopefully, of course, he is cognitively active and the progress is legitimate.

It is also hoped that the risk of the student merely being a passive recipient of the programme is further reduced by the introduction of deliberate discontinuities in the relative positions of successive frames used in the programmes, at points where, for example, the student is required to work out a problem before proceeding to the next frame, see Section 3.2. Each of these spatial discontinuities presents a minor challenge to the student, in that he is required to remain alert and to make an abnormally large movement of the image selector of the microfiche viewer in order to select the requisite image.

Naturally, the same form of directed programme, including spatial discontinuities, may be used when the programmes are presented in booklet form rather than on microfiche. For this reason, in the course of this research, the performances of students using self-paced programmes presented on microfiche were compared with that of students using precisely the same programmes presented in booklet form. The analyses of the pre-test and post-test scores of the two groups of subjects are included in the analyses in Sections 8.1 to 8.3 and 10.1 to 10.11. These show that under the experimental conditions there was statistically no significant difference between the objective performances of the groups.

Perhaps this is not surprising, for observation of the subjects using the booklets in this research, clearly showed that they were busily engaged in the process of turning pages of the booklets to and fro, under the directions of the programmes, and had little opportunity to simply skim through them. Nevertheless, some students found this frustrating, compared with the relative ease of selecting one frame after another, by means of the image selection pointer of the microfiche viewer, of the programmes presented on microfiche. Certainly, the majority of the subjects expressed a preference for the microfiche presentation compared
3.3.10 Advantages of the SIMPLE-System Contd.

with the booklet form in surveys that were conducted after the objective tests. Their views are recorded and analysed in Sections 11 and 12 of this report.

In addition, undoubtedly at least some of the weaker students were also influenced by what appears to be a pronounced negative reaction to books and a preference for alternative media. In this respect, the similarity of the microfiche viewer to the television set, from which rightly or wrongly most students gain much of their information, may also influence its ready acceptance by students.

Student attitudes are of course vitally important in this respect, irrespective of their performances under the relatively short-term experimental trials of this investigation.* For student attitudes, which in turn may be influenced by social status, ethnic background or other social factors, will inevitably play a large part in shaping the long-term success of self-instructional programmed-learning using microfiche.

* ANNETT, J., (1972). "The finding of 'no significant difference' has been very common in the field of programmed-learning and one must be careful in interpreting the results. Being unable to demonstrate a difference does not prove that there are no differences to be found, given a sensitive measure." (80).
4. PRODUCTION

In the course of the investigations into self-instructional programmed-learning using microfiche over the past three years, the programme design and production methods have been refined and more sophisticated methods have been employed. The methods investigated are described below.

1 Programme Design and Layout

In laying out the relative positions of the frames of the programmes on the microfiche, and in determining their content, that favourite stand-by, the chalkboard, was first used in this investigation. By subdividing a large chalkboard into 60 frames, corresponding to the 60 images of the microfiche then used, by means of a 5 x 12 grid, the researchers were able to outline on the board the content of each frame, and to determine the places for cartoons and for the spatial, (but not logical) discontinuities, see Section 3.2, in each programme.

Later the chalkboard was superseded by a whiteboard, similarly marked with a 5 x 12 grid. Naturally, for microfiche with different formats different layout grids are necessary. Finally, rather than writing directly onto the board, it was found to be more convenient to draft the content of each frame on a sheet of paper and then to fix the sheet to the board in the requisite position in the grid, by means of adhesive tape. This procedure is illustrated by Figure 4-1.

In the process, owing to the scale of the board, other members of the Research team and also members of the teaching staff of Kilkenny College of Further Education and the other Institutions involved, were able to participate, in order to ensure that no logical step in the information to be presented by the programme was overlooked.

In this way, the content of each frame was determined, not so much by a detailed theoretical analysis of the programme, but by a group discussion based on a knowledge of the relevant educational theories and personal teaching experiences. Having agreed on the content of the programme outlined on the whiteboard, it is then simply a case of filling in the full details of the content of each frame.

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* Markle recommends that the first draft of a programme be prepared by a designer working alone, and that the programme should then be inspected by a critical reader, who is not necessarily an expert in the discipline concerned. The method used by the researchers is in effect an extension of this approach. (81)
FIGURE 4-1  USE OF THE WHITE BOARD TO LAY-OUT A PROGRAMME
4.1 Programme Design and Layout Contd.

The use of the whiteboard and separate taped-on sheets for each frame has proved to be remarkably effective. At any time during the design and layout of the programme, frames may be interchanged or replaced with the minimum difficulty, while an overall perspective of the programme is retained by the programme designers. Using this technique many of the programmes used in this investigation were designed in 3 or 4 hours, so that with a team of 2 or 3 people, this represents 6 to 12 man-hours, see also Appendix 1.

2 Art Work

Before each frame of the programme can be photographed and reduced to an image of a microfiche, it is first necessary to produce a master of the frame at a size which is convenient for lettering, illustrations and for photography. In this investigation, the master for each frame was produced on standard A4-sized bond paper. This size has proved to be satisfactory in all the applications so far encountered.

1 Lettering

Initially, it was hoped that the majority of the lettering required in the texts of the programme frames would be produced by means of an electric typewriter with interchangeable typing elements, while any very large lettering would be provided in Letraset characters. This was moderately successful but unfortunately the larger characters produced by the typewriter tended to break up, in that the carbon deposit was not consistent or uniform. The use of a silk typewriter ribbon reduced this effect but it was, nevertheless, soon necessary to resort to a combination of typed, stencilled and Letraset characters in order to produce a consistent result with a range of character sizes.

This process, which required the services of both the Illustrator and the typist of the Research team, was considered to be unduly laborious and consequently all the lettering of recent programmes has been carried out by the Illustrator using a Headliner with interchangeable fonts. This not only produces a more consistent professional product but eliminates the need for a typist in the production of programmes. Figure 4-2 shows a Headliner composing machine.
4.2.1 Lettering Contd.
The Headliner produces lettering ranging in size from 12 point to 72 point in a variety of type styles, depending on the font used. In the main, the text of the programmes developed were printed in 18 point type, a size which was preferred by the students, after reproduction on microfiche, to the 12 point maximum type size of the electric typewriter formerly used.

A disadvantage of the Headliner is that it produces the type in only a single line on continuous sprocket-holed 35mm photographic material. Consequently, it is necessary to remove the surplus material, particularly when several lines of text are required, so that the resultant strips of lettering may be pasted onto an A4-sized sheet to produce the requisite master sheet. As a result, the production of the lettering for the programmes remains a labour intensive matter. This is analysed in Appendix 1, but for example, for an average programme, it might take 8 hours to produce the lettering using the Headliner and a further 20 hours to glue the lettering to the master sheets of the whole programme.

Because the edges of paper pasted onto the master sheets throw shadows, which are reproduced on the microfiche, transparent 35mm Headliner film was tried for the lettering in an attempt to avoid this problem. Unfortunately, this was not successful. Firstly, the film also casts shadows and secondly, no adhesive was found to be reliable in this application. Therefore, the alternative less expensive white opaque Headliner 35mm photographic paper was used instead, and the problems of shadows were overcome by first photocopying the completed master sheets and then microfilming the photocopies, see also Section 4.2.2.

For monochrome microfiche, black lettering on a white background is preferred for the A4-sized master sheets. Then when these are photographed using negative microfilm, the lettering is reproduced as white lettering on a black background. This polarity is retained when the microfiche is reproduced using the low-cost diazo process, see Section 4.3. As a result, when the programmes are used, less light is projected onto the screen of the microfiche viewer. This is considered, subject to further
4.2.1 Lettering Contd.

research, by most users to be less tiring to the eye than the case when black lettering on a white background is projected onto the screen. In addition, the use of a dark background to the lettering and illustrations, masks the effect of any dust or other foreign matter on the microfiche and reduces the distraction that this may cause.

The methods of lettering described above require relatively little capital investment at the expense of high labour costs. For example, an electric typewriter costs approximately $850, and must be supplemented by stencilling and Letraset. The use of a Headliner at a capital cost of approximately $3,200 can eliminate the need for stencilling and Letraset but as described, is nevertheless a labour intensive method.

A far more sophisticated approach for those planning the large-scale production of self-instructional programmes on microfiche is to use a phototypesetter. For a capital cost of approximately $17,000, a phototypesetter is available which accepts interchangeable fonts, each providing a selection of type-styles, from which by means of a keyboard both type-style and type size in the range of 5½ point to 36 point may be selected. In addition, by means of the keyboard the operator is able to lay out and position the text as required. A video screen, see Figure 4-3, enables the operator to monitor his or her progress and to make any necessary corrections or adjustments. After the layout of each line is completed, the required text is optically produced on 8 inch wide photosensitive paper, at a speed, depending on the content of the text, which does not delay a competent operator/typist.

Phototypesetters are widely used in the printing industry and greatly reduce the time taken for typesetting. Consequently, by using a phototypesetter, considerable savings in labour costs and an improvement in the quality of the product are to be expected compared with the relatively simple lettering methods used in this investigation. However, the researchers have not had the opportunity to further investigate the use of the phototypesetter in this application. Obviously, a phototypesetter of
4.2.1 Lettering Contd.

this type could also be used for a range of other departmental or institutional purposes, e.g. the production of prospectuses, brochures, etc., thus leading to other economies.

Alternatively, a commercial bureau is available, which will layout the frames, including both text and illustrations, of a programme from the programme designer's drafts, and then in turn produce a microfiche master of the programme, and duplicate copies for distribution. Details of the cost of this service are given in Appendix 1.

2 Illustrations

Like the printed text, the illustrations used in this investigation were generally first produced separately, and the finished illustrations were then glued to the A4-sized master sheets of the relevant frames of the programmes. In practice, the illustrations were added after the lettering had been affixed, and checked. When illustrations are prepared for use in self-instructional programmes using negative microfilm and diazo copies, it is necessary to so design the illustrations to ensure that their impact or clarity is not marred by the colour reversal. For example, it is generally necessary to use thicker black lines for line drawings than is normally the case. In the case of a complex illustration it may be necessary to first draw the illustration to a large scale, and then to photographically reduce it to the required size for attachment to the master sheet.

An alternative approach which has some visual impact is to draw the illustrations in white ink on black paper, and then to affix the illustrations to the white paper of the A4-sized master sheet. The lines of line-drawings are then reproduced photographically on negative film as black lines on a white background, the size and shape of which is determined by the size and shape of the original black paper glued to the master sheet.

The use of black paper for the illustrations also has the advantage that the shadows produced by the edges of the glued-on illustrations are not then visible. As stated in Section 4.2.1, it was found that when white paper is glued to the white A4-sized
4.2.2 **Illustrations Contd.**

Master sheet, the microfilm camera is very sensitive to these shadows and they are invariably reproduced, marring the result. The use of white opaquing fluid around the edges of the illustrations did little to reduce this defect. On the contrary, it should be noted that it is necessary to use white opaquing fluid sparingly for any corrections, otherwise this too can throw shadows that will be reproduced by the camera. However, it was found that these shadows may be eliminated, if any suspect sheet is first photocopied by means of a suitable photocopier, which is not sensitive to the shadows, and if the resultant photocopy is then microfilmed.

Considerable economies in labour can be made by printing any repeated illustrations or directions, for example the 'GO TO FRAME' statement, onto the white A4-sized master sheets by means of an offset machine. In the latter case, the illustrator then merely has to add the particular frame number. This technique also eliminates the need to affix repeated illustrations to the master sheets, and the associated difficulties caused by shadows described above.

4.3 **Monochrome Micro-photography and the Microfiche Master**

Having produced the A4-sized master sheets, it is then necessary to micro-photograph these to produce a microfiche master from which duplicates may be made for use by students and others. The microfiche masters used early in this investigation were assembled using a microjacket but later this method was rendered obsolescent by the acquisition of a step and repeat camera/processor.

1 **The Microjacket**

To produce a microfiche master using the microjacket, it is first necessary to photograph each A4-sized master sheet using microfilm. This was accomplished using a planetary 16 mm microfilm camera, giving a 20 X reduction, see Figure 4-4. Then after processing, the 16 mm film is assembled into a microjacket. As illustrated by Figure 4-5, the frames of a 16 mm microfilm either individually or in strips, may be manually slid into the jacket in the required positions. Alternatively, and much more conveniently, the film may be loaded into the jacket by means of a jacket loader, see Figure 4-6.
FIGURE 4-h  PLANETARY 16 mm MICROFILM CAMERA
4.3.1 The Microjacket Contd.

In this way a microfiche of the desired programme may be modified at a later date by removing or replacing images as required. The microjackets may be used by the students, but normally the loaded microjacket form of the microfiche would be retained in a master-file in the library-resource centre and only microfiche duplicates would be distributed to students. Using a suitable microfiche copier using the diazo process, monochrome duplicates of the fiche cost about ten cents each, and duplicates using the vesicular process are only slightly more expensive, see Appendix 1. The costs of the equipment used are also given in Appendix 1.

Using 16 mm microfilm and the microjacket means of assembly, 60 images can be accommodated on a microfiche. Microjackets are available that accommodate 35 mm film in addition to 16 mm film, but the latter has the obvious advantage of permitting more images to be accommodated on the microfiche. Since the 60 frames provided by the use of 16 mm microfilm and the appropriate microjackets were considered to be adequate for the programmes used in this investigation, without making the programmes unduly long, this number of frames was no impediment in this investigation.

The use of the microjacket is a relatively inexpensive and simple method. However, it has the disadvantages that there is a risk of damage to the film while it is being loaded into the microjacket, that the jacket can produce some optical aberrations which are reproduced on the duplicate copies of the master microfiche, and unless suitable facilities are available, the 16 mm microfilm must be sent for processing after exposure.

2 Step and Repeat Camera/Processor

The disadvantages of the microjacket are overcome by the use of a step and repeat camera/processor. The step and repeat camera/processor, see Figure 4-7, uses fiche-sized film, and as each original master sheet is photographed in turn by the camera (a 24 X reduction was used) the exposed image is placed in the appropriate position on the film. As a result, all the frames of the programme are placed directly onto the fiche-sized film.
4.3.2 Step and Repeat Camera/Processor. Contd.

Then after exposure the master microfiche produced is processed by a built-in photographic processor in approximately 90 seconds, in the case of the machine used by the Investigators. This machine provides a maximum of 98 images on the fiche, arranged in a 7 x 14 grid pattern. In Appendix 1 the relative costs of the production of master microfiche using the step and repeat camera/processor and by the jacket loading method are compared. The comparison shows that apart from the advantage of a better quality product, the step and repeat camera/processor has economic advantages above relatively moderate levels of production.

Alternatively, other more complex techniques are available that allow several hundred images to be accommodated on a single microfiche, should this be justified. A range of interchangeable index cards and lenses are available for microfiche viewers, so that they may be used with microfiche with different numbers of images. However, fiche with large numbers of images are considered more appropriate for reference material, than for self-instructional programmes, which in the opinion of the Investigators should be relatively short, in order to increase the chances that the students will successfully complete them.

3 Microfiche Duplicates.

Owing to the facilities that were available to them, the researchers used only diazo duplicates during their investigations. Duplicates reproduced using diazo film retain the same polarity as the images from which they are duplicated. Consequently, when silver halide microfilm is used to produce a microfiche master, the negative-appearing image of the microfilm master is reproduced, without reversal, by the diazo film.* As a result, the black lettering on the white A4-sized paper masters produced in this investigation, see Section 4.2.1, was reproduced on both the silver film and its diazo duplicates as white lettering on a blue background.

* For a review of the terminology used in producing duplicate and master microforms, see Avedon (82).
4.3.3 Microfiche Duplicates Contd.

The negative-appearing images produced have the advantage, as already stated in Section 4.2.1, that they result in less light being projected onto the screen of the microfiche viewer, and this is considered by most viewers to be less tiring to the eye than when black lettering on a white background is projected. In addition, the dark background masks the distraction of any dust particles or other foreign matter that may adhere to the microfiche.

However, a disadvantage of this process is that negative-appearing photographs and illustrations are produced. Of course, the latter need not be a disadvantage, providing the original illustrations are appropriately prepared for this purpose, but negative-appearing photographs are generally unsatisfactory.

The latter disadvantage is overcome by using vesicular film for the microfiche duplicates. Vesicular film reverses the polarity of the image from which it is duplicated. Hence, vesicular film may be used to reverse the negative-appearing image of the microfilm master to produce positive-appearing photographs and illustrations. This advantage is, of course, gained at the expense of projecting more light onto the screen of the microfiche viewer, and less masking of any dust particles, than when negative-appearing images are used.

Vesicular duplicates are slightly more expensive than diazo duplicates, see Appendix 1. However, compared with the diazo process, the vesicular process has the advantage that it is a dry process requiring no chemical treatment. In the vesicular process, exposure of the film to ultraviolet light leads to the decomposition of the special material used to form a gas. The film is then developed by heat, which expands the decomposed particles to form microscopic vesicles (bubbles). With transmitted light, the vesicles scatter the incident light to form the requisite dark areas of the image.

With the diazo process, on the other hand, exposed diazonium salt used, and the diazo image produced is converted to a coloured, more easily visible image by a suitable phenolic coupler. The latter is generally aqueous or gaseous ammonia.
4.3.3 Microfiche Duplicates Contd.

The former is more convenient, but with both, as a safety measure, s. cable ventilation is essential and emergency respiratory equipment should be provided, certainly with the latter. However, having referred to these precautions, the researchers wish to point out that they in no way wish to detract from the value of this process, which is widely used owing to its simplicity and reliability.*

The life expectancy of the microfiche diazo and vesicular duplicates under suitable conditions, that is protected from light and chemicals, e.g. stored in a plastic envelope in darkness, appears to be unlimited. However, this is still subject to the confirmation of long-term empirical studies. Certainly, under the practical conditions prevailing at Kilkenny College of Further Education, in which microfiche diazo copies are normally stored in conventional paper envelopes, and used in normal daylight or fluorescent lighting, there is no evidence of the fading of diazo copies which are 2 or 3 years old. Nevertheless, silver-emulsion film is the only medium conventionally used for archival materials. This is because only for this film are the archival properties proved, and also because only with this film are there established procedures for checking the quality of processing (84).

4.4 Colour Microfiche

At the time that this report was compiled, the production of colour microfiche was in its infancy in Australia. However, rapid developments are expected in this area and both colour microfilm and commercial facilities to produce copies of colour microfiche are expected to become readily available. For this reason, most small-scale users may be well advised to wait until these facilities are established rather than attempting to enter this field prematurely.

Compared with monochrome microfilm, colour microfilm cannot currently be readily obtained, and needs far closer control over its exposure time and the colour temperature of the lighting during exposure.

* For a more detailed comparison of the vesicular and diazo processes, see McGregor (83).
Nevertheless, the investigators were after some experimentation, able to produce a satisfactory colour frame using 16 mm colour microfilm, compatible with the microjacket assembly technique described in Section 4.3.1. However, because the duplicates of master colour microfiche, required for use by the experimental subjects, could not be produced commercially in Australia at the time of this research, this aspect of the investigation was deferred. Other educationists in South Australia have experimented more extensively with the production of colour microfiche and colour copies, and their work is reported elsewhere. *(85),(86).*

### Standards

The images of the microfiche produced early in this investigation were numbered 1 to 60 by the investigators, starting at the top left-hand image, then moving to the right along each row in turn. This had the advantage that when booklets were produced by the offset process from the same A4-sized masters as the microfiche, see Section 4.6, the page numbers of the booklets were conventionally numbered 1 to 60.

However, the images of the microfiche produced for later programmes were numbered in accordance with draft Australian Standard No. DR76001 and titled Microfiche A6 for Engineering and other Data. As shown by Figure 4-8, the recommended standard uses an alpha-numeric system of identifying the images of the microfiche.

As a result, when booklets were produced from the later A4-sized masters, which were numbered in accordance with the draft standard, the pages of the booklets were also numbered in alpha-numeric fashion, with section A followed by section B, etc. However, the subjects recorded no difficulty or objection to this system, and consequently it has been adopted for all programmes.

* It has been pointed out that there is no reason why captions cannot accompany colour photographs on single frames rather than being located on adjacent frames *(87).* The colour microfiche as part of a multi-media package is discussed by Meyer *(88).* See also references *(9), (23) and (24).*
FIGURE 4.8

TYPICAL SINGLE FRAME

TYPICAL DOUBLE FRAME

REFERENCE EDGE

NOTE: 60 FRAME FORMAT AND LOCATION ON MICROFICHE AS.
4.5 Standards Contd.

Unfortunately, no standard has so far been adopted for the optical system of the microfiche viewer. As a result, the number of 180° reversals produced by the mirror and lens systems of microfiche viewers varies between the different models that are available.

Consequently, it is not possible to so mark a microfiche to enable one to insert it into any viewer with the confidence that the projected image will be correctly oriented. The best solution at present is for each library-resource centre to standardise on one configuration of viewer and to mark its microfiche, for example, by the way the programme title is typed across the top of the fiche, in accordance with the draft standard, so that the polarity of use of the fiche in the viewer is unambiguous.

4.6 Programmes in Booklet Form

For the purposes of the comparison of the effectiveness of self-instructional programmes on microfiche with the identical programmes presented in booklet form, the same A4-sized master sheets, see Section 4.2, were used as the masters for both the images of the fiche and for the pages of the booklets. Methods of producing the microfiche are described in Section 4.3.

To produce the booklets, the conventional offset printing process was used. That is, an offset master was produced from each A4-sized master sheet of the programmes, and then the sheets of the booklets were printed on A4-sized bond paper in the normal way, using an offset printing machine. The addition of stapled thin card covers, suitably inscribed with the title of the programme, produced attractive booklets for student use.
Within certain limits, meaningful educational research evolves around the proper and adequate control of variables. Unless such control is achieved the researcher cannot be sure that the actual relation he discovers between his dependent and independent variables is genuine or at least has a high degree of probability of being genuine.

The control of variables is a complex matter but it basically involves control of variance. In other words, the researcher seeks to control the variance in one variable by reference to the variances in associated variables and so to "explain" the first variable in terms of the other variables (usually called "independent" variables for convenience).

Say we have a variable Y, which we will call the "dependent" variable, and a number of "independent" variables X1, X2, ..., X1, ..., Xn. How can we determine the contribution of Xi to the variance in Y?

There are two complementary approaches possible:
(a) direct experimental manipulation;
(b) statistical control.

Experimental manipulation of variables is usually accompanied by some statistical control but often statistical control must be applied to the available data over which the researcher has no direct control. In the present research, the researchers were able to employ both means of control with the primary emphasis upon statistical control.

The advent of sophisticated new computing techniques has revolutionised educational research in recent years. A multiplicity of statistical packages are now available which can be used to control and sort out a variety of interdependent variables and, depending upon the precise objectives of the research, to determine the degree of variance in one variable associated with any other variable and the statistical significance of such contributions.

This has permitted some degree of relaxation in the experimental manipulative procedures and, provided the relevant variables can be ascertained, meaningful results can be obtained with smaller samples than previously

In addition, the randomization procedures can be relaxed, if statistical procedures such as analysis of covariance are employed with the most important covariates and factors taken into account. *

Of course this does not mean that no attempt should be made to match groups and that ridiculously small samples can be used when experimental manipulation is possible. Generalisations to a parent population are clearly dangerous when samples are small and stand a high probability of departing significantly from population norms. What is being stressed is that the great improvements in statistical control procedures have made life much easier for the educational researcher and that he now enjoys a greater degree of flexibility than in the past. He can concentrate upon collecting as much useful data about his subjects as possible rather than upon minimizing the effects of secondary data experimentally, a procedure which is seldom completely possible in practice, even with the best experimental designs.

1. Introduction

In the present research variables were controlled by:

(a) direct experimental manipulation using experimental and control groups either randomly allocated or stratified upon the basis of some variable deemed important under the circumstances.

(b) statistical control using analysis of covariance with intelligence, pre-test scores, age and in some cases, other variables as covariates and teaching method as a factor, or using multiple

The analysis of covariance is a useful method of statistical control in situations where experimental control over extraneous variables is impossible or undesirable. It is a parametric technique and statistically tests for differences between adjusted rather than actual means. Of course the usual parametric assumptions should be met. See Section 5.3.1 or Wiersma (89). Cochran does make a warning regarding the use of analysis of covariance in non-randomized experiments. If all important variables are not taken into account then bias will still remain even after adjusting for one or two covariates (90). To overcome this, the researchers used as many pertinent covariates as possible. It should also be noted that if a variable such as method is processed first rather than after covariates, then effects of differences in samples will show up in the results for that variable.
5.1 **Introduction Contd.**

regression analysis with the predictor variables being processed in the appropriate order.*

The question of whether complete control of all relevant variables is possible in principle is a question which should concern the experimental researcher. If, as the Skinner school seems to suggest, such complete control is possible, then one can predict, to any decided upon degree of accuracy, how a human subject will respond to a given situation or stimulus-field.** While human behaviour does seem to be highly predictable, it remains true that, unlike physical objects or quantities, human beings do not always respond in a predictable or expected manner to a given stimulus. For the meaning of the stimulus, as perceived by the subject, is not always the same as that perceived by the experimenter or researcher.***

In this report there is no room to expand upon this question at length but suffice it to say that the thesis that all phenomena are explicable in terms of discrete variables which can be uniquely identified, isolated and measured, given sufficient refinement of measuring tools, is problematic. This notion, which is part and parcel of classical or Newtonian physics and traditional Western philosophy, has been shown to be inapplicable to modern physics and no longer enjoys complete philosophical primacy even in the Anglo-Saxon world which has long accepted it as an article of faith.****

* Multiple regression analysis is receiving increasing application in educational research. Kerlinger and Pedhazur write that it "is a powerful analytic tool widely applicable to many different kinds of research problems.... It can be used equally well in experimental or non-experimental research.... It can do anything the analysis of variance does and more. Handled with knowledge, understanding and care, it is indeed a general and potent tool of the behavioural scientist". (91)

** Skinner writes in a recent book that "It is in the nature of scientific progress that the functions of autonomous man be taken over one by one as the role of the environment is better understood". (92)

*** Silverman in a recent critique of traditional organisational theories points out that "What the observer takes to be merely the repetition of some physical action may imply totally different meanings to those concerned according to the way they define each situation". (93)

**** Cawthron and Rowell have discussed these matters with special relevance to science education in a forthcoming publication. (94)
5.1 Introduction Contd.

In practical terms this probably means that one cannot go on indefinitely identifying and controlling all pertinent variables in an educational experiment whilst proceeding to isolate and measure a specific variable or sub-set of variables. One can go a certain distance, just as one can with classical analytical methods in physics or biology but eventually one comes up against an unsurmountable barrier - the interlocking variables become so intertwined that further analysis becomes virtually meaningless. The more the experimenter tries to control the real situation, the less real and meaningful become his results and conclusions. This does not mean that educational research cannot be profitable, provided one is aware of its inherent limitations and does not try to make sweeping generalisations upon the basis of insufficient data or a too simplistic a view of human nature.

The "situation" in an educational experiment is thus considerably more complex than in a pure science experiment. In both cases the presuppositions of the experimenter introduce an element of subjectivity into the perceived situation but in the former case there are also the presuppositions of the subjects to take into account. These may introduce a reciprocity of expectation, which can be very subtle or so apparent as to be overlooked in the experimental situation.

Thus while the researcher may feel reasonably confident that he has accounted for most sources of variance, or lack of variance, in a given situation he cannot generalise broadly from his data without running a grave risk of being proven wrong under different circumstances where the subjective factors, as well as the purely physical and objective, are different.

What can be said is that, under the limitations of the present project, substantial as these are, certain conclusions may be drawn for the particular groups of subjects (and populations), particular programmes and topics, and particular teachers comprising the experimental situation. It will be up to further research conducted in other situations with various groups of subjects of differing biographical histories to determine whether further generalisations are feasible or permissible.

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5.1 Introduction Contd.

The statistical procedures used employed the SPSS (Statistical Package for the Social Sciences) (95) in most instances, the fixed effect model being utilized for these experiments (96). In both the analyses of covariance and multiple regression runs, the statistical programme usually first adjusted for sources of variance in the dependent variable due to other independent variables which could confound the effect of the particular independent variable, i.e. method, under consideration. *

The variables examined included pre-test score, first post-test score, second post-test score (in some cases a "retention test"), method of instruction, period spent at self-paced learning, intelligence, age, sex, mathematical ability, reading age, class or teacher, final mark in end of year or end of term exam and personality measures (for "introversion-extroversion" and "interest and concentration"). Not all of these were available in each instance and the researchers selected those which were deemed relevant and/or which were available. Usually, the dependent variable was first post-test or second post-test score, and method of instruction one of the independent variables (or more specifically a "factor" as it takes discrete values in the same way as does class, sex, or teacher) but the predictability of the final mark was also considered in some cases.

The pre-test and two post-tests were as identical in format as possible, the only difference being numerical alterations to the mathematical problems.** The internal consistencies of these tests, obtained by

* The use of programmed computer-packages can be criticised as open to the abuse of indiscriminate use. It is certainly essential that the researcher understands the statistical concepts underlying such packages but it is not feasible that the educational researcher should design all of his programmes from first principles. One need not be a skilled motor mechanic in order to drive a motor vehicle, but one must or should know how to handle one's vehicle! McCracken writes "... no one who actually wants to do statistical calculations should ever write his own programmes to do so! The proper approach is to use packages of subroutines written and tested by someone else who specialises in that kind of work". (97)

** The pre-tests were thus not measures of pre-requisite knowledge but of the initial pre-knowledge of the topic or subject matter proper before instruction was given. The present use of the term must therefore be carefully distinguished from its common usage.
5.1 Introduction Contd.

looking at the even and odd items as two sub-tests (using the SPSS Reliability programme) were found to be 0.8 to 0.9 and the distributions of scores were close to a normal distribution for the post-tests with no appreciable "ceiling effects".

The data employed in the analysis were raw score data, i.e. the actual test score marks. It was necessary to impose a 30 minutes (in most instances) time limit upon the time taken for the tests and so the tests measured speed, concentration and accuracy, as well as conceptual knowledge. This was unavoidable under the circumstances and probably contributed additional sources of variance to the results.

2 Discussion of Research Design

Specific aspects of the research design in the separate experiments will be discussed in a later section. Here some general considerations are discussed additional to those mentioned in Section 5.1, and some points are expanded upon further.

As Annett points out (Footnote to Section 3.3.10) "The finding of 'no significant difference' has been very common in the field of programmed learning and one must be careful in interpreting these results. Being unable to demonstrate a difference does not prove that there are no differences to be found, given a sensitive measure". The important consideration appears to be the amount of variance which can be accounted for in the dependent variable by all independent variables together. If this is only a few percent, then obviously the effects of method are going to need to be quite drastic to show up in the analyses.*

One solution is to use very large samples in which case even small amounts of explained variance become significant. However, if the researcher has to go to such lengths to gain statistically significant results, the latter lose applicability to most practical situations. Another solution is to carefully select pertinent variables to account for as much of the variance in the dependent variables as possible.

* Probably about 30-40% of variance at least should be accounted for but there are no cut and dried rules regarding the minimum.
5.2 Discussion of Research Design Contd.

With a high degree of experimental or statistical control, the effects of method of instruction (the factor of greatest interest in this research) if present at all, have more chance of detection. See also the discussion in Section 5.2.7.

1 Use of a Control Group

In the present project the objective was not to look at the feasibility of microfiche self-instruction as a teaching method per se but at its feasibility as an alternative or, more generally, a complement to conventional teaching or and to self-instruction using programmed booklets where practicable.

Thus the "lecture" or "control group" was actually one of the experimental groups. The "lecture" and other experimental groups were made as nearly equivalent as possible by an appropriate selection procedure - which differed slightly in individual experiments - and "objectively" defined as accurately as possible by carefully measuring variables believed to be relevant to the performance on the dependent variable (first or second post-test).

2 Effects of Experimental Procedure

All tests are themselves learning experiences and to measure the effectiveness of a teaching method the researcher should strictly use groups with and without pre-tests and with and without the application of the method.*

However, the objective, as previously stated, was not to assess the effectiveness of any particular teaching method per se, but to look at relative effectiveness. As all the subjects** were given the same tests it was assumed that any learning from the test would affect all equally. The result was a slight diminution in the overall sensitivity of the experiment so that "method" in the statistical analysis indicated both true method effects plus

---

* This is called the "Solomon Four Group Design". For discussions see Wiersma (98), Campbell and Stanley (99), and Travers (100).

** In this discussion "subject" refers to "pupils" or "students" and not to "topic" or "subject matter".
5.2.2 Effects of Experimental Procedure Contd.

Test effects. Any significant effect would reflect a method effect only if one ignores possible interactions between learning on the pre-test and method (or learning on the first post-test and method in the case of the analysis of the second post-test) (101).

3 Experimenter Contamination of Data

Travers (102) points out that such contamination is one of the commonest errors of educational research design. Briefly, it involves the tendency of the experimenter to accept with little hesitation the data which confirms his own expectations rather than adopt a critical stance and consider all data objectively. The tendency of the experimenter to hang on stubbornly to his theories reminiscent of the nature of a Kuhnian "normal" scientist who sees what he expects to see rather than exercising his critical faculties Popperian style.*

Whether it is possible to be completely objective is a philosophical question which continues to be hotly debated and will be raised later in this discussion.** However, it was possible to reduce the more overt effects of experimenter contamination by ensuring, for example, that only one person marked all tests, even IQ tests and that individual test papers were marked collectively without reference to, or knowledge of, the particular instructional method employed for the individual subjects (students). This at least reduces the temptation to be selective in acceptance or interpretation of data.

* Cawthron and Rowell write that 'The Kuhnian 'normal scientist' is not oriented so much to the pursuit and discovery of fundamental novelties of fact or theory, or to the Popperian testing of theories, as to the production by whatever means are 'acceptable' of expected solutions to prescribed problems - or puzzles - according to standardized procedures...'' (103). Readers interested in the debate are referred also to the major works of Kuhn and Popper, (104), (105), (106), (107) and to Lakatos and Musgrave (108).

** Subtle experimenter effects are probably almost impossible to eliminate completely and the best one can hope to do is to be aware of the phenomenon and to take steps to avoid the more overt effects as discussed in the text. On a more profound level it can be argued that any social science experiment contains subtle expectations which are built into the very structure and it is impossible, despite the assertions of some behaviourists, to separate the objective from the subjective characteristics in any profound sense.
5.2.3 Experimenter Contamination of Data Contd.

One possible source of contamination, over which little control was possible, was the lecturers' or teachers' knowledge of the contents of the tests which may have enabled them to concentrate unconsciously upon those particular items most relevant to the post-tests, whilst handling the control groups. Despite this, however, the lecture situation did not produce results which were statistically significantly better than programmed self-instruction in any experiment although for one set of data (combined "Simultaneous equations" data - see later) it nearly did so. Conversely, in a science test the reverse was the case.

4 Assumptions Regarding Scales Used

As mentioned previously, the reliabilities of the scales were found to be ~ 0.8 or more. In most cases split-half reliabilities or other measures of internal consistencies were calculated for representative tests and Cronbach's \( \alpha \) for the personality scales. As expected the inter-test score correlation was high especially between first and second post-tests, the mean test scores lying near the middle of the range so that the tests were neither excessively difficult nor easy for the students.

With pre-test, the correlation with first post-test was usually somewhat lower than between first and second post-tests, as many students, especially those tackling a relatively abstract topic for the first time, found the pre-test test beyond them. Thus the pre-test, although a useful covariate for controlling variance in the first post-test, was supplemented by intelligence and other variables deemed relevant for determining performance on the post-test following the learning experience.*

The test items were not all of equal difficulty, hence no assumptions were made regarding the equivalence of similar increments in test scores, i.e. an increase in mean score from 2 to 4 in

* Chronological age was included as an independent variable although intelligence test scores have already been age-adjusted in the conversion from raw scores. Thus in most cases "age" measures variance due to age not already taken out by intelligence.
5.2.4 Assumptions Regarding Scales Used Contd.
go from a pre-test to the first post-test was not assumed
equivalent to an increase from 6 to 8. However, because the
subjects in any experiment were all presented with the same
tests, and pre-test was used as a covariate or predictor in
all cases, this was not considered an important consideration.

5 Confounding of Variables
This occurs when subjects exposed to different methods are, at
the same time, exposed to differences in some other variables
which will affect the dependent variable, i.e. performance on
the post-test (109).

To some degree the problem is one of clarification of objectives.
For some research applications one may indeed be interested in
the practical situations where, for example, a small amount of
student-student, student-teacher or student-tutor interaction
occurs even with self-paced instruction. In others, complete
individualised instruction may be of interest. In the current
project some measure of inter-personal interaction was allowed
in some instances, see Section 7.4, while in others the students
worked completely alone.

Some confounding of variables is thus permissible, provided it is
adequately controlled. More serious are cases where different
teachers are used to deliver the lecture or lesson to different
subjects in the control ("lecture") group.

Because of the practical situation it was not always possible to
have only one teacher involved at a time. Thus the full-time
stage one technicians, described in Section 7.2, were taught by
a different teacher from the part-time students, and for the
experiment at the high school, involving over 200 subjects, see
Section 7.4, as many as 5 teachers were involved. Thus the
"lecture" results are in some cases "composite" and "class" or
"teacher" was included as an additional variable in the analysis.
This did lead to some interesting results as will be discussed
later in the relevant sections. Differential teacher effects, if
important, would be expected to show up in the second post-test
if the students are given several lectures or lessons during the
intervening period or in the final mark at the end of term or end
of year.

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5.2.5 Confounding of Variables Contd.
Another confounding variable was the diminution in the subject numbers in the lecture groups during the experiments vis-a-vis the normal situations. With up to two thirds of the class allocated to the programmed self-paced learning groups this possibly enabled the teacher to concentrate more on weaker students than would normally be the case. But this effect would enhance the lecture situation and the failure to find any significantly better results for the latter does nothing to distract from the feasibility of the programmed learning situation as an alternative or complement to conventional teaching.

.6 Selection of Groups
The procedures used for selection of the experimental and control groups in individual experiments will be discussed in the relevant sections. As sometimes successive runs in different experimental trials were carried out on the same or nearly the same subjects, it was not feasible to use purely random allocation to the control and experimental groups in all cases.

Pure randomization is probably most effective when large samples are available and simple statistical methods suffice. However, when numbers are small (40 or less) and adequate covariate data is available, and when one is engaged in an on-going research venture, it may not be crucial or even possible. Indeed the writers did use randomization in the case of the high school experiment, with approximately 70 in each group, and still found some differences in the groups in practice, see Section 9.1

.7 Effect of Sample Size
It is a well-known maxim in educational research that large samples are required to detect small effects, i.e. to achieve high sensitivity. In other words, large samples serve as one means of variance control. However, as Travers points out "If very large numbers of observations have to be made in order to obtain a reasonably accurate estimate of a difference, then it is doubtful whether a difference of that particular magnitude is large enough or consequential enough for the researcher to spend his time in further studies of the phenomenon" (110).
5.2.7 Effect of Sample Size Contd.

In any practical situation one is faced with a large amount of uncontrollable variance and small effects that only show up as significant with very large numbers of subjects are mainly of academic interest.*

The minimum permissible sample size therefore depends upon the objectives of the experiment and attempts to set minimum acceptable figures unfounded. If the researcher is interesting in looking for strong overt effects then quite small samples are permissible. The researcher may commence his research investigation with a pilot study involving relatively small samples and then, if results are encouraging, seek greater sensitivity by carrying out a more comprehensive investigation with larger samples.

In this research report several approaches are reported with subject population sizes varying from about 25 to 230 in the main study. Numbers in the various teaching situations vary from less than 10 to above 70. In all cases, statistical control (see Section 5.1) is utilized as much as possible.

8. Effects of Subject Expectations

The work of Mayo and his team at the Hawthorne works of the Western Electric Company in Chicago between 1927 and 1932 has been much cited in educational research. Applied to the educational setting the "Hawthorne Effect" predicts that groups singled out for study are likely to learn more than groups not thus identified. In the present case where even the "control" group is also an experimental group - and recognised as such by the subjects, the problem is not so much the "Hawthorne Effect" per se, but possibly differential effects due to some groups identifying more with the experiment than others.

* Many researchers apparently overlook the fact that significance levels do not "measure" degree of confidence. Rosenthal and Gaito (111) found that many members of a psychology department in a university had greater confidence in a given significance level for N = 100 than for N = 10. In fact, if the researcher does find a significant relationship for small N then it is more indicative of a strong effect in the population from whence the sample was drawn than for a larger N. Of course, at the same time, the sensitivity of the experiment is smaller.
5.2.8 Effects of Subject Expectations Contd.

For example, as microfiche is a novel instructional medium for most students, one might expect them to respond to it more positively than to the lecture situation. Whether this is an important consideration or not depends, in part, upon whether one envisages microfiche as an alternative or as a complement to conventional teaching. If the whole course is given in microfiche form then the novelty effect if this exists, may become inoperative after a period, but if one envisages a variety of teaching methods and media being made available as back-up resources, then novelty effects become part of the case for introducing such variety into the learning situations.*

The only sure way to settle the matter definitely is to compare the performances of subjects exposed to a particular method over an extended time-span (and this could also provide greater sensitivity, assuming all other relevant variables could be adequately controlled over the period, which is doubtful) and self-paced instruction is currently being introduced to complement some courses at Kilkenny College of Further Education.**

However, some light can be shed on the matter by analysing the interview data and/or comparing the relative effectiveness of microfiche and books. Novelty effects would, one expects, be considerably less for books than for microfiche.

* Bracht and Glass point out that there is also a disruption effect which acts to counterbalance the novelty effect. They write "An estimate of the novelty and disruption effects can be obtained by extending the experimental treatment over time. Even then, problems arise if the novelty or disruption of the treatment has led to the development of relatively permanent skills and traits in the experimenters and/or subjects" (112).

** Few researchers would advocate a curriculum consisting exclusively of programmes. Wallis et al found that after a week of working exclusively at programmes the work rate dropped and teachers were in demand again (113). Postlethwait is perhaps one of the best known advocates of Integrated teaching (114).
5.2.9 Effects of Experimenter Attitudes

This is, of course, closely related to Section 5.2.3 on "experimenter contamination of data" and could have been included there. However, it is worthwhile making a distinction as the experimenter may not only select or accept conclusions in accordance with his own expectations but may actually help to create the data from which he draws his conclusions. In other words, his data itself is not value free, a point which Kuhn also makes in his book, but contains a subjective element.*

Whether this so called "Pygmalion Effect", as it is sometimes called is a significant factor in educational research is often argued. In the present case, the effect would possibly manifest itself in the tendency, already referred to, for the teacher to perform better than average during the experiment as he feels that he personally is being evaluated as a teacher, rather than the teaching method itself. Also, the teacher by his attitude, e.g. when distributing questionnaire forms, could influence the response to the same.

Such extraneous sources of variance, if present, would probably tend to enhance the lecture method vis-a-vis the others. They should be accepted as part of the real situation as any teaching innovation must always be carried out in a human environment and attempts to create a completely artificial situation may well defeat the real usefulness of an educational experiment.

5.3 Discussion of Statistical Methods

1. Analysis of Covariance: Basic Concepts

The Analysis of Covariance is a method of statistical control of variance when complete experimental control is not possible (see Section 5.1). (115),(116),(117). For example, subjects who perform well on a post-test administered after the application of the various teaching methods may perform well or badly because of their good or

Cawthron and Rowell write "..... if Kuhn is correct, human response is determined not simply by sensory stimuli but by how the human agent views his world, or how he processes or programs stimuli, from that world. His data are not something 'out there' to which he has conscious access, facts are not theory free." (118).
5.3.1 Analysis of Covariance: Basic Concepts Contd.

Poor prior knowledge of the topic and/or because of their intelligence and general mathematic aptitude. Method effects will thus be confounded by the effects of other variables which must be "adjusted for" or "controlled" before method effects can be assessed.

In the latter case the direct effects of method on the dependent variable are assessed, i.e. adjustments to post-test scores are first made for the relevant covariates. However, total method effects can also be ascertained by testing for the significance of method first before adjusting for relevant covariates.

Some care is necessary in interpreting the total effect of a variable as it includes interaction effects, e.g. one teaching method may show a significant effect vis-a-vis another because intelligent subjects perform better at it. Once intelligence is adjusted for, however, such effects will fade out or rather be taken up by the effects of intelligence. A number of interaction effects may conceivably cancel one another out so that the total effect is less than the direct effect in some instances.

If the experimental and control groups are not exactly matched on some relevant covariate then the analysis of covariance will compensate for this in assessing direct method effects. However, if the actual allocation of groups is not completely random, the total effect will also reflect this via the interaction effects between the unrandomized variable and the dependent variable. Thus the study of interaction effects involving method should be accompanied by randomization or at least some attempt should be made to match the groups on the main covariates which could give rise to such effects.

In a distribution the variance is a statistic given by the sum of squares of the deviations about the mean normalized to \( N - 1 \)

\[
\sigma^2 = \frac{\sum (y_i - \bar{y})^2}{N - 1} \tag{ia}
\]

\[
= \frac{SS_y}{N-1} \tag{1b}
\]
5.3.1 Analysis of Covariance: Basic Concept Contd.

where \( SSy = \sum_{i=1}^{N} (Y_i - \bar{Y})^2 \) or sum of squares, \( Y \) the dependent variable and \( \bar{Y} \) the mean of \( Y \) over the whole sample (the grand mean)

If a factor \( A^k \) affects \( Y \) then

\[
SSy = \sum_{i=1}^{N} (Y_i - \bar{Y})^2
\]

\[
= \sum_{j=1}^{k} \frac{N}{j} (Y_{j} - \bar{Y})^2
\]

\[
= \sum_{j=1}^{k} N_j (Y_{j} - \bar{Y})^2 + \sum_{j=1}^{k} \frac{N}{j} (Y_{j} - \bar{Y})^2
\]

\[
= SS A + SSerror \quad \ldots (2)
\]

where \( \bar{Y}_j \) is the mean of \( Y \) in the category \( j \) and \( N_j \) is the number of cases in category \( j \).

\( SSerror \) is the variance which is not explored by \( Y \) and is referred to as the error term. If \( A \) has no effect upon \( Y \) then \( SSy = SSerror \) (= \( SWithin \) as it represents the sum of squares in \( Y \) due to the variation within each of the categories of \( A \)).

The SPSS computer print out includes, as part of the multiple classification table, the statistic

\[
\text{eta}^2 = \frac{SSA}{SSy} = \frac{SSy - SSerror}{SSy} \quad \ldots (3)
\]

which is the amount of variance explained by \( A \).

The relevant F ratio, to determine whether or not this is statistically significant is

\[
F = \frac{SSA/(k - 1)}{SSerror/(N - k)} \quad \ldots (4)
\]

where \( k \) = number of categories in \( A \). This gives us the probability that the departure from zero in (3) is due to chance fluctuations in the data. If \( F \) is sufficiently high then the departure is

* i.e. a variable which takes a series of discrete values or categories, \( 1 \ldots j \ldots k \).
5.3.1 **Analysis of Covariance: Basic Concept Contd.**

probably a genuine effect and will be valid for the parent population from which the sample is drawn.

With the presence of a covariate X, as well as a factor, a simple linear regression method is used to control the effects of the former.

If in the equation

\[ Y' = a + bX \]  

the correlation between the predictor variable X and the residuals \( Y - Y' \) is zero, Y is residualized on X, i.e. we have transformed Y into a variable \( \cdot \cdot Y' \) from which the effects of X have been removed.

If we now carry out tests of significance on the residuals of the various groups corresponding to different categories of A we can ascertain whether the groups differ significantly after their scores have been adjusted for possible differences in, for example, intelligence.

From (5) we can write

\[ \bar{Y}_j = \bar{V}_j - b(X_j - \bar{X}) \]  

where \( \bar{V}_j \) = adjusted mean of category j
\( \bar{V}_j \) = unadjusted mean of category i
b = regression coefficient
\( \bar{X}_j \) = mean of covariate for group j
\( \bar{X} \) = grand mean of the covariate.

If all groups are equal on the covariate (due to randomization for example, or deliberate matching) \( \bar{V}_j = \bar{V}_j \).

Individual values for Y will be given by the expression

\[ Y_{ij} = \bar{V} + T_j + b(X_{ij} - \bar{X}) + e_{ij} \]  

where \( \bar{V} \) is the overall grand mean of Y, \( T_j \) the effect of A, and the other symbols are self-explanatory, \( e_{ij} \) the error term. (7) can be written in the form

\[ Y_{ij} = b(X_{ij} - \bar{X}) = \bar{V} + T_j + e_{ij} = Y_{ij} \]  

79
5.3.1 **Analysis of Covariance: Basic Concept Contd.**

showing that the adjusted score is equal to the sum of the grand mean, a treatment term and an error term. Of course, this method only removes the linear effects of X involving, as it does, a simple linear regression.

The procedure is now to calculate $SS_A$ and $SS_{error}$ as before and obtain

$$\text{beta}^2 = \frac{SSA}{SS_y}$$

....(9)

which is called the standardized regression coefficient, and then to calculate the F value to test for statistical significance of A.

The SPSS computer programme will adjust $Y$ for the effect of the covariate X before testing for significance to see whether a significant amount of unexplained variance can be attributed to A.

The significance of X will also be pointed out, indicating whether or not it does indeed make a substantial contribution to the variance in Y. A simple regression is made of X on Y, the sum of squares calculated, averaged and then divided by the averaged sum of squares still remaining after the effects of A and X have been taken out.

Alternatively a researcher may select to test for the significance of A before testing for the significance of X. However, if one is looking at the effects of teaching method, for example, Y will usually be adjusted for the effects of X first.

The above discussion can be extended to cases of more than one covariate and more than one factor. In the case of 2 factors, say A and B, the computer will calculate the sum of squares $SS_{A,B}$ due to the interaction between A and B and $SS_{A,B}$ the sum of squares due to the additive effects of A and B, as well as $SS_A$ and $SS_B$.

The expression (3) for $\eta^2$ now becomes

\[
\text{multiple } \eta^2 = \frac{SS_y - SS_{error}}{SS_y} = \frac{SS_{A,B}}{SS_y}
\]

....(10)
5.3.1 Analysis of Covariance: Basic Concept Contd.

where SS A, B, AB, the joint effects of factors A and B and their interaction, has replaced SSA.

SSAB is defined by the difference

\[ SSAB = SSA, B, AB - SSA, B \quad \ldots(11) \]

and SSA and SSB are adjusted for the other factor as follows

\[ SSA, \text{ adjusted for } B = SSA, B - SSB \]
\[ SSB, \text{ adjusted for } A = SSA, B - SSA \quad \ldots(12) \]

The significance of the factors A and B can now be tested by the usual formulae (analogous to 4) with

\[ SSA, \text{ adjusted for } B \quad \text{(written } SSA.B) \]
\[ SSB, \text{ adjusted for } A \quad \text{(written } SSB.A) \]
\[ SSA.B \]
\[ SAB \]

or

\[ SA, B, AB \]

as the appropriate sums of squares in the denominator.

Usually these are not all performed. The usual procedure is to

(1) test the significance of SAB (the interaction)

then

(2) test the significance of SSA, B (the additive model)

then

(3) test the significance of SSA.B and SSB.A.

If SSA.B is significant then it need not follow that the one or both of the individual main effects need be significant. In general

\[ SSA, B \neq SSA.B + SSB.A \]

and the disparity will increase as the association between the factors increase.

The SPSS computer print-out contains F values and significance levels for SSA.B, SSB.A, SA.B and SAB.
5.3.1 Analysis of Covariance: Basic Concept Contd.

Alternative formulations for SSA,B are possible. In the 'hierarchical approach' we may, for example, write

\[ SSA, B = SSA + SSB.A \]  

If we have reason to believe A is causal to B (i.e. B is in part due to A). In this case, if SSA,B is significant, then either SSA or SSB.A will also be significant.

In the 'regression approach' each effect is examined after the effects of all other variables and their interaction are adjusted for, so that F tests are carried out on SSA,B,AB, SSA,B,AB, SSB.A,AB and SSAB.A,B for example.

In the present project there is no known causal order among the factors and the main effects have a higher priority than the interaction effects. Thus the first or 'classic' approach was used with regression procedures utilized, as described above, to remove variation in the dependent variable due to the covariates.

.2 Multiple Regression Analysis: Basic Concepts

A recent development in educational research has been the use of multiple regression as a means of control of variables in order to evaluate the actual contribution to the explained variance of a specific variable or set of variables (119)(120).

Multiple Regression Analysis is, like Analysis of Covariance, a method for control of confounding variables in order to evaluate the contribution of a specific variable in cases where complete experimental control is not possible. Indeed, it may be regarded as a generalised analysis of covariance with the distinction between factors and covariates less pronounced. Both types of independent variables may be processed together through the use of dummy variables for categorical variables such as teaching method or sex (see Section 5.3.4). Analysis of covariance however becomes only one aspect of multiple regression analysis, the main emphasis of which is on prediction of the dependent variable from the independent variables.
5.3.2 Multiple Regression Analysis: Basic Concepts Contd.

The SPSS regression subprogramme supplies a series of statistics which will now be briefly discussed.

In the expression

\[ Y' = A + BX \]  \hspace{1cm} (14)

\( X \) is the predictor variable and \( Y' \) the predicted value of \( Y \) (previously in the discussion of analysis of covariance the symbol \( A \) was used to denote a factor and \( b \) the regression coefficient) (See equation (5)).

The residuals \( Y' - \bar{Y} \) are a minimum when the coefficient is

\[ B = \frac{\sum (X - X)(Y - \bar{Y})}{\sum (X - X)^2} \]  \hspace{1cm} (15)

(the subscripts used in the analysis of covariance discussion, are dropped for simplicity)

and the \( Y \) intercept is

\[ A = \bar{Y} - BX \]  \hspace{1cm} (16)

If we write

\[ \sum (Y - Y')^2 = SS_{res} \]  \hspace{1cm} (17)

then

\[ \sum (Y - \bar{Y})^2 = \sum (Y' - \bar{Y})^2 + \sum (Y - Y')^2 \]  \hspace{1cm} (18)

gives

\[ SS_y = SS_{reg} + SS_{res} \]  \hspace{1cm} (19)

where

- \( SS_y \) = total sum of squares in \( Y \)
- \( SS_{reg} \) = sum of squares explored by the regression equation
- \( SS_{res} \) = sum of squares not explored by the regression equation.

The computer subprogramme supplies a statistic called the standard error of \( B \) which is given by \[ \sqrt{\frac{SS_{res}/N-2}{SS_X}} \]

and also the \( F \) value for \( B \) given by

\[ F = \frac{SS_{reg}}{SS_{res}/(N-2)} \]  \hspace{1cm} (20)
5.3.2 Multiple Regression Analysis: Basic Concepts Contd.

Thus if $B$ is estimated from a sample, size $N$, we can establish its confidence levels to any percentile using Student's $t$ distribution and we can also test hypotheses concerning the parent population for which the sample was drawn.

The simple bivariate case can be extended to the multivariate case, i.e.

$$Y' = A + B_1X_1 + B_2X_2$$

where $B_1$ and $B_2$ are now called partial regression coefficients.

If we keep $X_2$ constant or "control the variable $X_2$" for each change of one unit in $X_1$, $Y'$ will increase by $B_1$ units. (18) can be written as a bivariate expression

$$Y' = A + B_1X_1$$

where $X_1 = (X_1 - X_1')$

and $X_1' = A + B_1X_2$.

Thus the partial regression coefficients enable us to examine the changes in the dependent variables due to changes in one independent variable as the other independent variables are held constant.

The expression (19) also holds in the multivariate case. The overall predictive accuracy or goodness of fit of the regression equation can be evaluated by the square of the multiple correlation between $Y$ and the independent variables as expressed by the equation

$$R^2 = \frac{SS_y - SS_{res}}{SS_y} = \frac{SS_{reg}}{SS_y}$$

( = simple correlation between $Y'$ and $Y$)

$R^2$ is the proportion of variance in $Y$ explained by the independent variables and is provided as part of the computer print-out.

The computer also prints out beta weights for the regression coefficients, these being referred to as standard regression co-
5.3.2 Multiple Regression Analysis: Basic Concepts Contd.

Coefficients as they are computed on standardized X and Y values (i.e. X and Y standardized to unit variance).

What renders multiple regression analysis particularly useful and powerful is the use of semipartial and partial correlation coefficients to measure the contributions of the independent variables more directly than is possible from the B coefficients.

Considering the case of 2 independent variables X1, X2 we can define the semipartial correlation as

\[
ry(1.2) = \frac{ry1 - ry2 r12}{\sqrt{1 - r12^2}}
\]

where the r's are the simple or zero order correlations between the relevant variables. The computer calculates this useful quantity, the square of which is also given by

\[
r^2y(1.2) = R^2y.12 - R^2y.2 \quad (= R^2y.12 - r^2y.2)
\]

or the absolute variance \(\Delta R^2\) in \(R^2\) due to the addition of \(X1\) to the equation already containing \(X2\).

The partial correlation is given by

\[
ry1.2 = \frac{ry1 - ry2 r12}{(\sqrt{1-r^2y2})(\sqrt{1-r^212})}
\]

and its square is the proportional reduction in unexplained variance, i.e.

\[
r^2y.1.2 = \frac{R^2y.12 - R^2y.2}{1 - R^2y.2}
\]

Analogous equations can be obtained for more than two variables. If we wish to generalise to populations we now have available a number of \(F\) values depending upon our specific research objective. For convenience we will summarise these as follows.

(a) We can calculate the overall \(F\) for all independent variables, \(F2\). This is given by an extension of expression (20):

\[
F2 = \frac{SS_{reg/k}}{SS_{res/(N-k-1)}}
\]
5.3.2 Multiple Regression Analysis: Basic Concepts Contd.

\[
R^2/k = \frac{(1-R^2)/(N-k-1)}{....(28)}
\]

where \( k \) = number of independent variables and \( N \) = sample size.

(b) We can calculate the F value for each independent variable by treating it as if it had been added to the regression equation last. Designating this "F4" we can write

\[
F_4 = \frac{R^2_y(1.12......k)/1}{(1 - R^2_y.12......k)/(N-k-1)} \quad ....(29)
\]

\[
= \frac{(\text{additional variance accounted for by variable I added last})}{\text{(unexplained variance) }/ (N-k-1)}
\]

(c) We can calculate the F value designated F3, for each independent variable by treating it as if it was added first, second or at some other pre-determined level in a hierarchy. Thus for the I-th variable (entered on the I-th step)

\[
F_3 = \frac{R^2_y(1.1.............I-1)/1}{(1 - R^2_y.12.....k)/(N-k-1)} \quad ....(30)
\]

\[
= \frac{(\text{additional variance accounted for by variable I added at I-th step})}{\text{(unexplained variance) }/ (N-k-1)}
\]

(d) We can calculate the F value at each step taking the "unexplained variance" as the variance unexplained at that stage. Thus "F to enter or remove" F1 obviously will be the same as the F in case (b) for a variable added last but when variables are added in a hierarchical order, the "unexplained variance" must be calculated for each variable. In this project only forward regression was employed so variables were entered into the regression equation as they were processed and not removed subsequently.

The SPSS print-out with appropriate selections of options includes all of these F values together with significance levels except (c) which is readily calculable from the summary table which is included in the computer printout.
5.3.3 Residual Analyses

SPSS subprogramme Regression will print-out and plot the residuals \( Y - \hat{Y} \) upon request.

These residuals should be normally distributed about the regression line if the basic assumptions of the linear model are tenable. "Goodness of fit" to the normal distribution is readily tested with a \( \chi^2 \) test and deviant cases or outliers can be located. If these are numerous and grouped about some specific range of \( Y \), the dependent variable, then the statistical procedure may need modification or revision. For example, a transformation of the scales may be tried to remove the curvilinear effect when the relationship between the dependent and independent variables is clearly non-linear. Or additional interaction terms of the form \( X_1 \cdot X_2 \) can be computed and added to the regression equation.

In the present experiments, violations of statistical assumptions were not sufficiently serious to warrant this attention, with the residuals not departing significantly from normality and being distributed about the mean with approximately the same variance throughout the full range of \( Y \).

4 Use of Dummy Variables

To conclude this section we will make a brief reference to the use of dummy variables in multiple regression analysis (121)(122).

Briefly the researcher "creates" a set of dichotomous dummy variables for each factor or categorical variable. In the present project the usual procedure was to create dummy variables for teaching methods by issuing the relevant instructions to the computer thus.

\[
\begin{align*}
\text{IF} & \quad (\text{METHOD EQ 1}) \ D_1 = 1 \\
\text{IF} & \quad (\text{METHOD EQ 2}) \ D_2 = 1 \\
\text{IF} & \quad (\text{METHOD EQ 3}) \ D_3 = 1
\end{align*}
\]

For three teaching methods the third IF statement given is, in fact, redundant as it supplies the computer with no additional information. Only two of the dummy variables \( D_1 \), \( D_2 \) and \( D_3 \) will be included in the computer print-out.
5.3.4 Use of Dummy Variables Contd.

If "lecture method" has been designated the arbitrary label of 1 then D1 will be given the value 1 when the computer reads 1 at the appropriate site on the data card for a subject (student). The regression analysis then proceeds as before, and the significances of the various F values including D1 (and the other method dummy variables) duly computed.

With dummy variable analyses it is possible to investigate interaction effects of the form D1X, D2X, D3X, etc. whereas the SPSS analyses of covariance subprogramme which does not use dummy variable, cannot handle such "covarlate-factor" terms.

5 Multiple Regression and Sample Size

Obviously the larger the sample the more reliable and reproduceable are the regression statistics. On the other hand, if samples are too large, even small correlations between variables will become statistically significant for the experimental situation, though of limited practical application, see Section 5.2.7.

Probably about 50 subjects in each teaching group would give a reasonably accurate estimation of the effects due to teaching method with 3 or 4 predictors, especially if one used the "adjusted values for $R^2$" rather than the unadjusted values. The adjusted value of $R^2$ is given by the formula (123).

$$R^2_{adjusted} = R^2 - \frac{(k - 1)(1 - R^2)}{N - k}$$

or alternatively arranged (124)(125)

$$R^2_{adjusted} = 1 - (1 - R^2) \frac{N - 1}{N - k}$$

where $k$ = number of coefficients estimated (independent variables and constant, if used). Briefly, $R^2_{adjusted}$ is more accurate for cross validation purposes because the regression fit for a sample will always take advantage, as it were, of idiosyncracies of the sample and thus overestimate $R^2$ (126). Both are included in the computer print-out.

In the present project, except for the high school experiment, see Section 7.4, which involved about 70 subjects in each group, the number of subjects per group numbered about 25-30 in cases where
5.3.5 Multiple Regression and Sample Size Contd.

Multiple regression analysis was employed. Thus the adjusted $R^2$ values were sometimes considerably less than the unadjusted values and the statistical reliability of the computer print-out results probably small.

Nevertheless, the primary objective was not to make the value of $R^2$ as large as possible, e.g. by making the number of effective predictors an appreciable contribution to the explained variance. The exact or actual values of $R^2$ or incremental values in $R^2$ were not as important as whether the method variables show up as significant for the particular samples of subjects under consideration. Replication of results by a number of researchers in a number of situations alone can lead to broader generalizations.
6. PILOT STUDY: 1975

The principle of the 'SIMPLE SYSTEM' was devised by the Chief Investigator early in 1974 (127), and during 1974 investigations into the viability and production methods of self-instructional programmes on microfiche began. However, it was not until 1975, with the aid of a grant from the Education Research and Development Committee (then the Australian Advisory Committee on Research and Development in Education) and the provision of additional microform equipment by the South Australian Department of Further Education, that substantial progress was made. The grant enabled the employment of a full-time research assistant, a part-time illustrating assistant and a part-time office assistant, and also met the cost of the materials and other equipment used during the research.

The principle of operation of the 'SIMPLE SYSTEM' was found to be readily accepted by students during the course of the investigations in 1975 and 1976, and therefore has not been changed. This method is described in Section 3.2 of this report. The progress made up to the end of 1975 was described in an earlier report and elsewhere (128)(129). Because of the favourable results obtained, a further grant was awarded by the Education Research and Development Committee to enable this work to continue in 1976. As a result, the 1975 study in effect formed a pilot study for the more substantial investigation conducted in 1976.

1 Theoretical Considerations in Programmed-Learning

During 1974 and 1975, the researchers devoted a considerable amount of their time to reading papers on the theoretical considerations to be taken into account when designing self-instructional programmes, and also to library searches in an endeavour to see whether similar empirical research had previously been conducted. However, with one exception, no record of similar work could be found. Encouraged by their reading, and by the fact that no similar research of any substance seems to have been previously conducted, the researchers determined to pursue this project.

The theoretical considerations are summarized in Section 3.3, of this report. That section describes some of the learning theories relevant to programmed-learning, and it should be noted that while not all of these theories were considered in 1975, for many were read subsequently.

Reference to the investigation carried out by L.W. Watchel was made in Section 1. (1:0).
6.1 Theoretical Considerations in Programmed-Learning Contd.

none conflicted with the basic principles used in the design of the self-paced programmes used in the course of this research project.

2 Production

The greatest part of the practical work carried out during 1974 and 1975 was devoted to developing an efficient means of producing self-instructional programmes on microfiche. While the principle of producing a master for each frame of a programme, on A4-sized sheets and then reducing it photographically for assembly on microfiche, is fairly straightforward, various subtle technical difficulties had to be overcome to produce an acceptable product. The production methods developed by the end of 1975 are substantially those described in Section 4 of this report. However, at that time, the programmes were laid-out using chalk on a chalk board, and it was not until later that the superior method of using the white board for programme layout was developed.

In addition, it was not until 1976 that a Headliner was obtained to produce the lettering of the programmes. Prior to that, the lettering was produced by a combination of the use of an electric typewriter, the use of a Letraset and by stencilling.

Further, it was not until 1976 that a step and repeat camera/processor was obtained. Since this greatly simplifies the production of the master microfiche for the self-instructional programmes, this superseded the earlier production method. The latter used a simple planetary camera and a jacket loader as described in Section 4.3. of this report.

2 Experimental Design and Results

Owing to the necessity to develop a satisfactory means of producing self-instructional programmes on microfiche, and the time taken to do this, it was not until the second half of 1975 that empirical trials could be conducted with students using the self-instructional programmes produced on this medium. The techniques of experimental design and statistical analysis are described in some detail in Section 5 of this report, and therefore will not be pursued in depth here. Instead, however, the procedures used and the results obtained in 1975 will be summarized.

In 1975, 16 students enrolled in a subject titled "Preparatory Mathematics"
6.3 Experimental Design and Results Contd.

participated as the experimental subjects in the research project. The Preparatory Mathematics subject, which is studied on a part-time basis for 6 hours per week for one term (13 weeks), is designed as a bridging-course in mathematics for those students who have not satisfactorily completed third-year secondary studies, including a pass in mathematics, and who wish to enter the Radio and Television Servicing course also conducted at Kilkenny College of Further Education. These students were selected because classes taking this subject typically include students having very widely differing cognitive abilities and educational and work experience. Consequently, their individual needs are not necessarily met in a didactic teaching situation and it is hoped that these students, in particular, may benefit from self-paced programmes, when these are freely available.

In order to assess the effectiveness of self-instructional programmed-learning using microfiche, in 1975, using the limited number of 16 students available, the performance of students taught mathematical topics by this means, was compared with that of students taught by the conventional didactic teaching method. The 16 students were divided into two groups. In an effort to overcome the diversity of ability and experience of these students, they were not allocated to the two groups by a simple random means. Instead, the students were first stratified by age, and the youngest was then assigned to one group, the next two youngest students to the second group, then the next two youngest students assigned to the first group and so on. This process was repeated until all the students were assigned to the two groups. Interestingly, although analysis for 1975 showed this to be a valid procedure, the results subsequently obtained with other groups in 1975 showed that this method was unnecessary, see Section 7.1.1. of this report. Consequently, in the later studies described in this report, simple random assignment of the students to groups was used.

Two mathematical topics were used in the course of the 1975 Investigation, namely, "Powers of Ten" and "Introducing Algebraic Equations". As these titles imply, the former refers to the manipulation of positive and negative powers of ten, and the latter refers to the transformation of simple algebraic equations. With the first topic, one group was taught by a self-instructional programme, while the other was taught by conventional didactic teaching, and later with the second topic, the groups were interchanged.

For each topic, both groups concurrently sat a Pre-test in the topic prior
6.3 Experimental Design and Results Contd.

to instruction. Then each group received instruction for a pre-determined maximum duration, one group exposed to didactic teaching and the other to the self-instructional programme. The students using the latter worked as individuals, using separate microfiche readers, and to further reduce the risk of extraneous effects modifying the results, they received no additional academic assistance during the experimental period.

It should be noted that in 1975 the self-instructional programmes were therefore not self-paced for the slower students, as their study was curtailed when the pre-determined time had elapsed. This was for two reasons, one the practical difficulty that the students had only limited attendance time, and the second was an attempt to gain greater control over the experimental conditions. However, in the later investigations described in this report, self-paced conditions were more nearly approached for those students using the self-instructional programmes. At the end of the instructional periods, both groups sat a Post-test. However, those students who finished the self-instructional programmes early, were allowed to sit the Post-test as soon as they were ready.

Table 6-1 shows the maximum instructional periods allocated to the two mathematical topics.

**TABLE 6-1**

**TEST AND INSTRUCTION DURATIONS**

<table>
<thead>
<tr>
<th>PROGRAMME</th>
<th>MAXIMUM DURATION (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PRE-TEST</td>
</tr>
<tr>
<td>Powers of Ten</td>
<td>20</td>
</tr>
<tr>
<td>Introducing Algebraic Equations</td>
<td>20</td>
</tr>
</tbody>
</table>

Unfortunately, after the 16 students had been allocated to the two experimental groups, not all the students presented themselves on the days of the experimental trial. As a result, only 13 students actually took part.
6.3 Experimental Design and Results Contd.

Before the trials comparing self-instructional programmed-learning and conventional teaching began, the ACER Higher WL and WQ intelligence tests were administered to the students. An examination of the significance of the difference between the two means of the composite W(L + Q) IQ's of the two groups gave an independent t ratio of 0.64 which, with 11 degrees of freedom, is not significant at the 0.05 level, indicating that there were no adequate grounds for rejecting the null-hypothesis that the groups were similar with this measure. Thus indicating that the method of allocating the students to the two groups was a satisfactory procedure.

1 First Mathematical Topic

The results obtained by students studying the "Powers of Ten" topic taught by self-instructional programmes and by conventional teaching are shown in Tables 6-2 and 6-3 respectively. The independent t ratio of the Pre-test scores of the two groups is 0.442 which, with 11 degrees of freedom with a two-tailed test, indicates that the differences between the two groups was not significant at the 0.05 level. As a result, again there were no adequate grounds for rejecting a null-hypothesis that the initial abilities of the two groups of students were similar.

An examination of the Pre-test and Post-test scores of the experimental group of students for the significance of the difference between the two means shows that the dependent t ratio is 8.57, which for 4 degrees of freedom, with a two-tailed test, shows that the self-paced learning was having a significant effect at the 0.001 level. Similarly, for the control group the dependent t ratio is 5.18, which is also significant at the 0.001 level, in this case for 7 degrees of freedom with a two-tailed test. This shows that the conventional teaching method also had a significant effect.

Conversely, an examination of the significance of the difference between the two means of the Post-test scores of the experimental and control groups, shows that the independent t ratio of the Post-test scores is 0.774, which at the 0.05 level shows there are no adequate grounds for rejecting a null-hypothesis that programmed-learning is as effective, so far as is determined by these measurements, as didactic teaching.

ACER Higher Test - Forms M & W (1973) (131)
### TABLE 6-2

**EXPERIMENTAL GROUP (PROGRAMMED-LEARNING) - TOPIC 1**

<table>
<thead>
<tr>
<th>STUDENT</th>
<th>AGE</th>
<th>WL</th>
<th>WQ</th>
<th>W(L + Q)</th>
<th>PRE-TEST*</th>
<th>POST-TEST*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>24</td>
<td>88</td>
<td>107</td>
<td>98</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>110</td>
<td>94</td>
<td>103</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>19</td>
<td>100</td>
<td>96</td>
<td>97</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>18</td>
<td>95</td>
<td>89</td>
<td>91</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>E</td>
<td>20</td>
<td>86</td>
<td>104</td>
<td>95</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
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<td>7.38</td>
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### TABLE 6-3

**CONTROL GROUP (CONVENTIONAL TEACHING) - TOPIC 1**

<table>
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<tr>
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<th>WQ</th>
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<th>PRE-TEST*</th>
<th>POST-TEST*</th>
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<tbody>
<tr>
<td>F</td>
<td>23</td>
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</table>

* Scores out of 20
6.3.2 Second Mathematical Topic

After the two groups of students had been interchanged, the results shown in Tables 6-4 and 6-5 were obtained when the two groups respectively received instruction by the alternative methods in the topic titled "Introducing Algebraic Equations". In this case the independent t ratio of the Pre-test scores of the two groups is 0.02, which, with 11 degrees of freedom for a two-tailed test, is not significant at the 0.05 level, again indicating that the groups were similar.

An analysis of the Pre-test and Post-test scores for the experimental group of students showed that the t ratio was 0.76, which, for 7 degrees of freedom with a two-tailed test, at the 0.05 level, shows there are no adequate grounds for claiming that the programmed-learning method was having a significant effect. Similar results were obtained with the conventional teaching method, for which the dependent t ratio is 0.80, with 4 degrees of freedom with a two-tailed test. These results show that the instructional period, which was based on the time traditionally allocated to this topic, was inadequate. As a result, the research unintentionally unearthed an anomaly in the previous teaching methodology.

However, an examination of the significance of the difference between the two means of Post-test scores of the experimental and control groups given in Tables 6-4 and 6-5, shows that the independent t ratio is 0.115. For 11 degrees of freedom, with a two-tailed test, this shows that there are no adequate grounds for rejecting a null hypothesis that the programmed-learning method was as effective as the conventional teaching method, so far as is determined by these measurements. Needless to say, in the later investigations using this topic described in Section 7 of this report, greater time was allocated to the instructional period.

In addition, the data described above, were analysed by means of an analysis of covariance carried out using the ANOVA (Analysis of Variance) sub-programme of the SPSS (Statistical Package for Social Studies) computer programme (132). The objective was to gain familiarity with this analytical technique so that it might be used with
### TABLE 6-4

**EXPERIMENTAL GROUP (PROGRAMMED-LEARNING) - TOPIC 2**

<table>
<thead>
<tr>
<th>STUDENT</th>
<th>AGE</th>
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<th>PRE-TEST*</th>
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<td>99.75</td>
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### TABLE 6-5

**CONTROL GROUPS (CONVENTIONAL TEACHING) - TOPIC 2**

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<th>STUDENT</th>
<th>AGE</th>
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<th>WQ</th>
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<th>PRE-TEST*</th>
<th>POST-TEST*</th>
</tr>
</thead>
<tbody>
<tr>
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<td>88</td>
<td>107</td>
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<td>7</td>
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<td>2.59</td>
<td>9.71</td>
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</tbody>
</table>

* Scores out of 20
6.3.2 Second Mathematical Topic Contd.

confidence in 1976. This method of analysis is described in some detail in Section 5.3.1.

Using this programme to analyse the Pre-test and Post-test results of Topic 1 "Powers of Ten" and taking the Pre-test scores as the covariates, gives an F ratio of 23.84. This ratio shows that the covariates are very significant, that is, the Pre-test scores are very good predictors of the Post-test scores. Similarly, an analysis of variance carried out by the programme after the adjustment of the Post-test scores for the effects of the covariates, the Pre-test scores, produces an F ratio of 0.41, confirming that there was no significant difference between the effectiveness of the self-instructional programmed-learning and conventional teaching methods used.

Similar results were obtained when an analysis of covariance was applied to the Pre-test and Post-test scores, obtained with the topic "Introducing Algebraic Equations". In this case, an F ratio equal to 22.41 was obtained, again showing that the Post-test scores are very highly correlated with the Pre-test scores, and after adjustment of the Post-test scores, an F ratio of 0.029 was obtained, again confirming that there was no significant difference between the effectiveness of the two instructional methods.

Obviously, the results obtained with such a modest number of subjects, have limitations. However, they were sufficiently favourable to give the researchers an incentive to pursue this work further. Further, it may be concluded that, subject to these limitations, the assignment of the experimental student population to the two groups used was satisfactory, in that it was considered to be suitably free from bias and enabled the effectiveness of self-instructional programmed-learning using microfiche to be compared with conventional teaching under the given test conditions.

Interview Data

Because, irrespective of the empirical results obtained under test conditions, student attitudes will no doubt play a large part in shaping the success of self-instructional programmes on microfiche,
6.3.3 Interview Data Contd.

the researchers considered it important to gain the students' subjective views on this method of instruction, compared with conventional teaching. For this reason, semi-structured interviews of between 15 and 20 minutes duration were held, with each available student of the population used for the 1975 study. Unfortunately, two of the students who had participated in the experimental trials had subsequently dropped out of the course and could not be traced. However, three students who had not participated in the trials but who were in the same class group, later used self-instructional programmes for study and revision purposes and were interviewed to gain additional information.

On the question of primary importance to this Investigation, that is the attitudes of students to self-instructional programmed-learning using microfiche, the results were particularly favourable. Without exception, the 14 students interviewed approved of it and were in favour of its wider use. Possibly, this unanimous verdict was partly attributable to the reactivity of the interview situation, for in 1976, while the students expressed strong support for this means of instruction on a written questionnaire, they did not show such unanimity, see Sections 11 and 12.

Nevertheless, it should be noted that given a choice between conventional classroom teaching and self-instructional programmed-learning using microfiche, with the latter used by students in isolation, 9 of the 14 students preferred the former, invariably on the grounds that it permitted questions to be put to the teacher. However, of the 9 students who preferred conventional teaching to the self-instructional method, 5 indicated that they would be prepared to take the course in the programmed-learning format, owing to the advantages of flexible study times and pace that it offers. Further, 12 out of 14 students thought that self-instructional programmed-learning with simultaneous access to an academic tutor, for example, in a resource centre or study post, is a more desirable and beneficial means of study than isolated study. Lastly 8 students thought that their

Regrettably, relatively high drop-out rates are not uncommon in bridging-courses, often owing to a combination of motivational and other personal problems. This demonstrates the need for additional assistance to these students, many of whom have educationally disadvantaged histories.
6.3.3 Interview Data Contd.

studies using self-instructional programmed-learning using microfiche would benefit by working in small groups, while 5 preferred individual study. This matter was immaterial to the remaining student, who was a deaf mute.

The research carried out in 1976 took due note of the students' comments. For example, in the cases where available student populations were sufficiently large, the performances of experimental groups containing students working in small groups as well as students working individually, were investigated.

Conclusion

Hence, as mentioned earlier in this section, the 1975 study, by resolving most of the production techniques, and by clarifying the objectives and experimental procedures to be adopted, in effect formed a pilot study for the far more extensive investigation carried out in 1976. The researchers were therefore most gratified that at the end of 1975 the Education Research and Development Committee considered the project to be worthy of further support. Without this support the 1976 study would have been considerably attenuated.
This Section discussed the experimental procedures employed during 1976. In Section 5.2, some general aspects of the experimental design* were discussed which were generally the same for each experiment. However, there were differences in detail as well as in individual objectives which require elaboration.

1 Investigation Using Preparatory Mathematics Classes

The Preparatory Mathematics course is a one-term bridging-course designed to bring students up to the required pre-requisite mathematical level for further studies at Kilkenny College of Further Education (see Section 6 titled "Pilot Study"). The following topics were investigated:

(a) Algebraic Equations (first term class)
(b) Simultaneous Equations (first term class)
(c) Powers of Ten (second term class)
(d) Simultaneous Equations (second term class).

1 Algebraic Equations

For topic (a), Algebraic Equations, the 58 subjects in the class were stratified by age into 5 groups.** At this stage it was hypothesised that, due to the diversity in backgrounds and ages of the preparatory mathematics class, age would be a significant factor in determining test performances. (This was not, in general, confirmed by the subsequent analyses of results however).

* To summarize, the experimental procedure comprised the following steps, administered in the order shown:
  a) Intelligence test.
  b) Pre-test of fixed maximum duration.
  c) Instruction by lecture or self-paced programme.
  d) First post-test of same duration as the pre-test given as soon as possible after instruction.
  e) Second post-test of same duration as the pre-test given nominally one week after instruction.

During this week the self-paced students had access to the means of programmed-instruction relevant to their experimental group but the exact date of the second post-test was not revealed in advance to the students (usually referred to as "subjects" in the main discussion).

** The actual procedure was to constitute the groups by allocating the youngest subject to one group, the next youngest to another group and so on till the sixth subject was allocated again to the first group and then the others allocated in the same group order as before.
7.1.1 **Algebraic Equations Contd.**

The groups were then allocated randomly among the 5 teaching situations leading to four self-paced or "experimental" groups and one "control" group as follows:

- **Group One** (8 subjects) received a 33-minute lecture on the topic by an experienced lecturer who was also the regular classroom lecturer for 3 of the group.
- **Group Two** (7 subjects) worked individually through a self-paced programme on the topic using microfiche.
- **Group Three** (10 subjects) worked through the same self-paced programme using microfiche but in small groups - 2 groups of 3 subjects each and 2 groups of 2 each.
- **Group Four** (8 subjects) worked individually through the self-paced programme on the topic using booklets.
- **Group Five** (9 subjects) worked through the self-paced programme on the topic using booklets but in small groups - one group of three and three groups of two.

The four self-paced groups worked, nominally at least, at their own speed and the starting and finishing times of each subject were recorded.

As the above numbers indicate, only 42 of the 58 enrolled subjects actually presented themselves for the experiment after groups had been allocated, of which they had no prior knowledge. Despite the incomplete groups, there was still no statistically significant differences between the ages of the groups.

The actual procedure on the night of the experiment was as follows:

(a) the College Counsellor gave the subjects an IQ test consisting of the A.C.E.R. WL and WQ tests of 15 and 20 minutes duration respectively.* With preliminaries and a short break between sections, this took about 40 minutes.

(b) the lecturer who was to give the lecture to Group One told the subjects which groups and sub-groups to which they were allocated.

* Subsequently, scores are combined and converted to "IQ" after adjusting for chronological age. (133)
7.1.1 Algebraic Equations Contd.

(c) after a 15 minutes break the subjects went to their designated separate venues where they were given a 20 minute pre-test on the topic.

(d) the subjects then received instruction on the topic either self-paced from microfiche or booklets as individuals or in small groups, or from the lecturer depending upon their group.

(e) the subjects were then given a post-test immediately after their instructional periods. (For self-paced subjects the post-test was given as soon as they finished the programme).

There was thus a formidable programme which each student completing three tests and one lesson in the one normal lecture period. Nevertheless, student co-operation was good and all applied themselves conscientiously to all tests as far as could be ascertained by the supervisors.

The supervisors for the self-paced groups did not assist in any way with the instruction and apart from answering an occasional technical query regarding the operation, e.g. focussing of the microfiche viewers, took a completely passive role, only recording starting and finishing times for the pre-test, post-test and self-paced instruction for each subject.

Having the pre-test and post-test respectively immediately before and after the lesson probably served to increase control over extraneous sources of variance. Nevertheless the IQ test had apparently tired the subjects mentally as the increase in achievement between pre-test and first post-test was only marginally significant (see Table 8-1). Given 30 minutes to complete the tests the subjects would probably have shown a greater increase in test score. The SPSS computer print-out indicated that 76% of the variance in the post-test could be accounted for by the pre-test and other independent variables, e.g. intelligence and age.

Following the above, a second post-test was administered without prior warning exactly one week afterwards. Like the pre-test and first post-test it was of 20 minutes duration and of identical format, with only the numerical values changed in the problems.
7.1.1 Algebraic Equations Contd.
Although the sample sizes were very small, it was still possible, especially in view of the close control over relevant variables, to look for gross method effects by comparing all the self-paced subjects who worked individually with those who worked as members of groups, or all self-paced subjects who worked with microfiche with all those who worked with books, etc. No method effects were statistically significant across the population (a term used here to refer to the complete class from which the individual samples are drawn), suggesting that there were at least no gross method effects in this case.

Of importance was also the subjects' reaction to the microfiche machines and booklets. Subjects appeared to take more readily to the former than to the latter and the small groups worked collectively through the programme quite well, although the situation could not have been entirely self-paced for the slower members. At the end of the evening, most who had worked on the machines expressed interest in coming back to work on programmes in their own time and expressed their view that it was a valuable teaching aid. The attitude of students to programmed booklets was less than enthusiastic.

2 Simultaneous Equations (first term)
After the administration of the second post-test for "Algebraic Equations" (see above) the subjects were again allocated to five groups and told to assemble in their respective areas after a 10 minute break.

The groups were, as far as possible, kept the same as for "Algebraic Equations" but the allocation of groups to the various teaching situations was now as follows.

Group One (now 9 subjects, 8 of whom were the same as before) was again the lecture or "control group" and this time received a 60 minute lecture on the new topic.

Group Two (now 8 subjects, 7 of whom were the same as before) worked individually through a self-paced programme on the topic using booklets.
7.1.2 Simultaneous Equations Contd.

Group Three (now only 6 subjects, all of whom were in the group for the previous topic) worked through the self-paced programme working on booklets in small groups (3 groups of 2). Group Four (now only 5 subjects, all of whom were in the group for the previous topic) worked individually through the self-paced programme on the topic using microfiche. Group Five (now 8 subjects of whom 6 were in the group for the previous topic and 2 were new subjects who had been previously absent) worked through the self-paced programme working on microfiche in small groups (4 groups of 2).

We see that, although the available population was not exactly the same as before, most of the subjects who had previously worked as individuals on one of the self-paced methods now worked as individuals on the alternative self-paced method and similarly, for the subjects who had worked on self-paced methods in small groups. The lecture group remained essentially the same as before. The self-paced groups had thus received some prior practice in self-paced instruction which was no longer entirely "novel".

Upon arriving at their respective areas the procedure was similar to that for the previous experiment. A pre-test was administered, the lesson completed and then a post-test administered, the tests all now being of 30 minutes duration to give a more substantial increase between pre-test and post-test. Although the proportionate increase in score was indeed greater and more statistically significant (see Table 8-1) the absolute marks were considerably less as the subjects, irrespective of teaching method, found the topic more difficult to grasp in a single lesson.

This time the independent variables accounted for a little over 60% of the variance in the first post-test and again method effects were not statistically significant.

At this point, the experimental procedure departed from that for the previous topic. Owing to the students' timetable, instead of administering the second post-test at the next week's lesson, it could not be administered until the subjects had received three additional lecture/tutorial periods on the topic "simultaneous
7.1.2 Simultaneous Equations Contd.

equations' and related topics. As there were three regular lecturers involved in teaching first term preparatory mathematics, this gave an opportunity to look for "teacher effects" as a rough check on the sensitivity of the experiment. In fact, teacher effects did show up strongly on the second post-test, see Table 8-2(d). In this case, of course, was not strictly a "retention test". For Tables 8-1 and 8-2(d), see Section 8.

This concluded the first term investigations with the preparatory mathematics class. Most students, apart from those in the control group, had been given the opportunity to work at both forms of self-paced instruction and thus, hopefully, to give meaningful responses to the attitudinal questionnaire distributed late in the term, see Sections 11 and 12.

3 Powers of Ten (second term)

With the second term preparatory mathematics class the situation was complicated by the fact that a considerable proportion of the class, about 20%, was repeating from first term. It was decided to stratify the new students by age, as before, but to allocate the repeating students randomly to the groups so that each contained the same number of students with prior experience of the various teaching methods.

It was also decided, in view of the considerably reduced population size, only 29 subjects, to retain only two teaching methods, conventional teaching and individualised self-paced learning using microfiche.

The experimental procedure was similar to that for "Algebraic Equations" the new students being given an IQ test and then all students a pre-test, followed by the lesson and a post-test immediately afterwards, with a second post-test one week later.

Two subjects did not sit for the IQ tests because of late arrival and these were not included in the subsequent analysis, reducing the effective population size to 27. Of these 13 were in the microfiche group and 14 in the lecture group, the lecture lasting for 37 minutes. As before, all starting and finishing times were duly recorded.
7.1.3 Powers of Ten Contd.

In this case 70% of the variance in the first post-test was accounted for by the Independent variables and again method was having no statistically significant effect.

It will be recalled that "Powers of Ten" had been used in the 1975 pilot study. Although that study had not been self-paced, as the subjects using the microfiche had been set a time limit of 30 minutes (the average time taken by the self-paced subjects above was a little over 40 minutes) it was considered a worthwhile additional exercise to "combine the data" giving a total population for this topic of 40, with 21 effectively in the microfiche group and 19 effectively in the lecture group. The variance accounted for in the first post-test only dropped back from 70% to about 65% and once again no method effects became evident in the analysis.

.4 Simultaneous Equations (second term)

We saw that in an attempt to increase effective sample size only two groups were used for the topic "Powers of Ten".

In order to further increase the effective sample size, it was decided to repeat the topic "Simultaneous Equations" again, this time with the second term class and to only use two groups. Then, by combining the data with first term data obtained under identical or near identical conditions, a reasonably high population could be obtained for purposes of statistical analysis. In fact, the numbers were sufficiently high to enable some tentative conclusions to be reached using a multiple regression analysis, see discussion of results in Section 8.1.3.

The subjects who had been in the lecture group and microfiche groups for the "Powers of Ten" topic were now interchanged. The lecture group numbered 12, of whom 8 had been in the microfiche group for "Powers of Ten" and the microfiche group numbered 15, of whom 13 had been in the lecture group for the latter topic.

The experimental procedure was the same as before. Unlike the "Simultaneous Equations" experiment in first term, however, there was no second post-test from a previous experiment to sit for immediately before the pre-test. As in the first term case, how-
Simultaneous Equations Contd.

ever, the absolute increase in marks was quite small, although statistically significant, because of the conceptual difficulty many students found with the topic.

The second post-test was administered one week after the first. Only one lecturer presented the second term Preparatory Mathematics Course and so there were no "teacher effects" to show up in the analysis. This lecturer was also the one who gave the lecture to the control group in all experiments with the Preparatory Mathematics classes.

The net result was an effective population of 49, with 22 in the lecture group and 27 in the microfiche group. In addition, 15 could be added from the first term booklet groups, giving 42 in all for the self-paced situation and a total population of 64.

In this "pooling of data" all fiche (and all booklet) groups have been combined as the purpose was not, in the first instance, to distinguish between the small group and individualised situations. As expected the proportion of variance in the first post-test was reduced somewhat, to about 53%, but the statistical analysis again indicated that method was not making a significant contribution to this "explained variance". By "significant" it is meant "significant at the 5% level" but the F value for method did in fact reach the 0.084 level with a beta of 0.19, giving 0.04 (or 4%) of the variance attributable to method. This was confirmed by a multiple regression analysis which gave 0.03 as the contribution to $R^2$ from method. The marginal superiority was with the lecture situation in this instance.

Investigation Using Stage One Mathematics Classes (full-time & part-time)
The Stage One Mathematics 1 students had commenced their Electronic and Electrical Technician Certificate courses proper and had already at least achieved the level of mathematical ability given by the Preparatory Mathematics class. As Table 7-1 shows, their characteristics are considerably different from the Preparatory Mathematics class, they are not only somewhat younger (especially the full-time students) but of considerably higher IQ. All subjects were male with the exception of one first term Preparatory Mathematics and one Stage One Science student.
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<th>CLASS</th>
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<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>121.0</td>
<td>179.6</td>
<td></td>
</tr>
<tr>
<td>Preparatory Maths</td>
<td>3. Powers of</td>
<td>Mean</td>
<td>97.4</td>
<td>25.5</td>
<td>27</td>
</tr>
<tr>
<td>(2nd Term)</td>
<td>Ten</td>
<td>S.D.</td>
<td>10.8</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>116.0</td>
<td>129.7</td>
<td></td>
</tr>
<tr>
<td>Mathematics I</td>
<td>4. Vectors</td>
<td>Mean</td>
<td>113.7</td>
<td>20.0</td>
<td>34</td>
</tr>
<tr>
<td>(1st Semester)</td>
<td></td>
<td>S.D.</td>
<td>9.7</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>94.4</td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td>Full-time †</td>
<td>5. Complex</td>
<td>Mean</td>
<td>112.7</td>
<td>20.6</td>
<td>29</td>
</tr>
<tr>
<td>Numbers</td>
<td></td>
<td>S.D.</td>
<td>8.6</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>74.0</td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td>Mathematics I</td>
<td>6. Complex</td>
<td>Mean</td>
<td>115.9</td>
<td>24.1</td>
<td>67</td>
</tr>
<tr>
<td>Part-time †</td>
<td>Numbers</td>
<td>S.D.</td>
<td>9.1</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>82.1</td>
<td>49.2</td>
<td></td>
</tr>
<tr>
<td>Science</td>
<td>7. Inductive</td>
<td>Mean</td>
<td>115.7</td>
<td>24.4</td>
<td>49</td>
</tr>
<tr>
<td>Part-time †</td>
<td>Reactance</td>
<td>S.D.</td>
<td>9.4</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>88.8</td>
<td>69.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Capacitive</td>
<td>Mean</td>
<td>114.7</td>
<td>24.9</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Reactance</td>
<td>S.D.</td>
<td>9.7</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>83.6</td>
<td>74.0</td>
<td></td>
</tr>
</tbody>
</table>

*For convenience "population data" is used here to refer to the total population of subjects who took part in the investigation for a given topic, to distinguish it from "group data". In a strict statistical sense, of course, "population" refers to the greater totality from which the subjects were drawn, and the subject population is the "sample". In deriving the standard deviations listed in the table, N-1 was used rather than N.

**In some cases these are less than the initial population sizes owing to incomplete sets of subject data.

†Stage One Students.
7.2.1 Vectors (first term: full time)

As this involved the Mathematics I full-time class, it was conducted during the day rather than the evening. The group allocation procedure was similar to that described for the Preparatory Mathematics "Algebraic Equations" class and, as in that case, five groups were employed thus:

(a) lecture group or "control group" (10 subjects)
(b) "microfiche as individuals" group (7 subjects)
(c) "microfiche as small groups" group (5 subjects - 1 small group of 2 and one of 3)
(d) "booklets as individuals" group (8 subjects)
(e) "booklets as small groups" group (7 subjects - 2 small groups of 2 and one of 3).

Of these, one subject each from the "lecture" and "booklets as individuals" groups were unable to sit for the post-test, while one subject from the "microfiche as groups" group had not sat for an IQ test. These were dropped from the analyses, reducing the effective population to 34.

The pre-test (30 minutes duration) was administered by the regular lecturer who then allocated the students to their various groups and sent them to their respective locations. While the lecture or "control group" received a 38 minute lecture on the topic from the lecturer, the four self-paced groups worked through the programme containing identical material (the lecturer taught the topic using one of the programmed booklets as a guide in this case). After the lesson, a 30 minute post-test was administered, and a second post-test one week later. During this week the subjects did attend one tutorial class in which they were asked to work on a sheet of problems, some of which had a bearing on the topic but there was no formal instruction. Thus the second post-test in this instance was not strictly a "retention test", although Table 8-5 shows the performances on the two post-tests to be nearly identical.

As in the case of "Algebraic Equations" the results for this topic are only indicative, due to the use of 5 teaching situations and the small numbers of subjects in each sample. Nevertheless, any
7.2.1 Vectors Contd.

gross differential effects should still show up across the methods, e.g. method (acting through both the individualised and small group situation) effects proper or effects due to differences between the small group situation and the individualised situation.

Although 66% of the variance in the first post-test was accounted for, method effects were again not statistically significant, even though there was some suggestion that the "microfiche as individuals" group performed marginally better than the others. Interestingly enough, age showed up as an important covariate in this case, possibly because some older students found it more difficult to grasp abstract concepts during the instruction period for this topic, see Section 8.2 for full discussion.

2 Complex Numbers (second term - fulltime)

It was noted above that there was some suggestion that the "microfiche as individuals" group performed better than the other 4 groups, but because of the small numbers in any group this was possibly a group effect per se, rather than reflecting the viability or effectiveness of the method. It was thus decided to combine the subjects of the 2 previous book groups into one book group and the two previous microfiche groups into one microfiche group, reducing the number of teaching situations to three, i.e. the lecture and the two individualised self-paced situations.

For "Complex Numbers" the microfiche group was now switched to the lecture situation and the lecture group to the microfiche situation. Some from the booklet group were now allocated randomly to the new microfiche group to bring its numbers up to those for the new lecture group and the remaining students in the booklet group treated as an experimental group in the usual way.

The above interchange was possible because, unlike for Preparatory Mathematics, a one term course, the stage one Mathematics course extended over two terms. Nevertheless, there was some inevitable wastage so that the new population size was only 29 compared to the 34 for "Vectors".
7.2.2 Complex Numbers Contd.

The actual groups which took part in the experiment were as follows:

(a) Group 1 - 'Lecture group' (11 subjects of whom 8 had been in the microfiche groups for the previous topic, 2 of whom had not participated in the previous experiment and one of whom had been in the 'booklets as groups' group for that experiment).

(b) Group 2 - 'Microfiche group' (11 subjects of whom 7 had been in the lecture group for the previous topic, 2 of whom had been in the 'booklets as individuals' group and two had not participated in the previous experiment).

(c) Group 3 - 'Booklet group' (7 subjects all of whom had been in one of the booklet groups in the previous experiment).

The experimental procedure was much the same as for "Vectors" except, of course, that there were only 2 self-paced groups and these were now completely individualised.

"Complex Numbers" is a quite abstract topic although part of the conceptual groundwork had been laid down in the "Vectors" section of the course. Because the topic effectively introduced a new number system, the pre-test no longer served as quite as good a covariate as previously, but its contribution was still significant to the 0.002 level. Only about 50% of the variance could now be accounted for, to which method made no significant contribution. There was a suggestion that the lecture group performed marginally better than the self-paced groups, tending to confirm the view that these small differences are due to slight differences in the samples rather than any true method effects.

3 Complex Numbers (second term - part time)

In order to substantially increase sample size while continuing to maintain a tight control over extraneous variables, the above full-time data was amalgamated with data gathered from about 70 part-time students completing the stage one Mathematics course at Kilkenny College of Further Education.

The procedure again conformed to the basic pattern outlined at the beginning of this Section but, due to the larger student numbers involved, some modification was necessary. The part-time students
7.2.3 Complex Numbers Contd.

Attended one from a choice of three lectures once a week on one of two evenings, two classes being held on Monday evenings and one class on Friday evenings. The students also attended tutorial classes before or after the lecture sessions, allowing some degree of flexibility with times. Two lecturers were involved, one of whom took a class on both Monday and Friday evenings and the other of whom took the second class on Monday evenings.

On a week-by-week basis the procedure was as follows:

(a) Week One  
IQ tests administered.

(b) Week Two  
Pre-test administered as part of the tutorial classes by the tutors (in 9 out of the 10 tutorials this was the regular lecturer).

(c) Week Three  
Tutorials cancelled and the students allocated to their respective groups (see below). The lecture or control group received a 43-45 minute lecture from one of the regular lecturers (and it comprised two separate groups taught by two different lecturers) while the self-paced groups worked through the same subject matter using microfiche. A post-test was then administered.

(d) Week Four  
Second post-test administered one week after first post-test.

The decision to concentrate on two methods, the lecture and self-paced learning by individuals on microfiche, was prompted by a wish to increase the sensitivity of the experiment to see whether any subtle method effects would show up with the larger samples. On the other hand the loss in sensitivity owing to the practical necessity of having the pre-test a full week before the experiment necessitated some attempt to regain sensitivity by other means, viz by increasing sample sizes. The combination of full-time with part-time data also introduced an additional source of variance, as not only were three different teachers involved but also a broader age range of students, probably with differing degrees of motivation.
7.2.3 Complex Numbers Contd.
This time, due to the larger numbers available, a randomization procedure was used to allocate the part-time students to one or other of the two groups.

The statistical analysis indicated that with the "combined data" and a total of 88 students, about 30% of the variance in the first post-test could be accounted for, with method making no significant contribution. While the amount of variance accounted for is thus considerably less than in previous experiments in this investigation, the near complete absence of direct method effects suggests that they are minimal.

3 Investigation Using Stage One Science Class (part-time)
This investigation, which was carried out in third term, involved part-time students studying for the Electronic and Electrical Technicians Certificates at Kilkenny College of Further Education. Many of these students had participated in the last investigation as part of the Mathematics I class and so had received prior practice with microfiche, either at the time of that experiment or subsequently by private study in the College resource centre.

For convenience the two science/engineering topics used, inductive and capacitive reactance, will be discussed together as the two experiments overlapped for reasons that will become clear as the discussion proceeds.

Week One: the subjects were given a pre-test (30 minutes) on the topic "Inductive Reactance".

Week Two: the subjects were randomly assigned to two groups one of which received a 50 minute lecture on the topic from the regular classroom lecturer and the other (self-paced group) worked through identical material on microfiche. A post-test was then given immediately afterwards. The sample sizes were 27 in the lecture group and 22 in the microfiche group.

A perusal of the results indicated that the microfiche group had performed considerably better than the lecture group. However, because of the still small sample sizes, this could have been due to the sample itself rather than the method. It was therefore decided to
7.3 Investigation Using Stage One Science Class Contd.

test the subjects once again, with a similar but not identical topic, with the groups interchanged.

The topic "Capacitive Reactance" was selected and the appropriate programme and tests compiled as soon as possible. The construction of the programme was quite straightforward as it only involved modifications to the "Inductive Reactance" programme. While the conceptual base was quite similar for the two topics, "Capacitive Reactance" was still sufficiently novel to serve as a topic in its own right.

The experimental procedure now proceeded as follows.

Week Three : the subjects were given a pre-test on the topic "Capacitive Reactance".

Week Four : the subjects were assigned to two groups again, one of which received a 50 minute lecture on the topic "Capacitive Reactance" from the regular classroom lecturer and the other (self-paced) group worked through the same material at a self-paced rate on microfiche. A post-test on the topic was given immediately afterwards.

The lecture group now contained 24 subjects, of whom 23 had been in the microfiche group for the topic "Inductive Reactance". The other student had not participated in the previous experiment. The microfiche group now contained 20 subjects, of whom 19 had been in the lecture group for the topic "Inductive Reactance", the other student not having participated in the previous experiment.

The slight student wastage between the two experiments leading to a reduction in population size from 49 to 44 was unfortunate, but unavoidable, due to the usual drop-out rate at this time of year when some students apparently found the burden of work too much for them or had changed their employment or interests. However, as the above figures show, the "dropping out" affected both groups about equally so far as numbers were concerned.

Week Five : this was a non-experimental week as it contained some public holidays. No tests or experiments were carried out during this period.

Week Six : the second post-test for "Inductive Reactance" was administered.
7.3 Investigation Using Stage One Science Class Contd.

Week Seven: the second post-test for "Capacitive Reactance" was administered.

The tests for these experiments (Stage One Science) were all marked by the lecturer involved whereas all other tests in this report were marked by the Research Officer for this project. The lecturer had compiled the content of the programmes in conjunction with the members of the Research Team. (In previous topics the actual compilation had been largely the work of the Research Team). All tests were near identical in format (for both topics) with only the values changed in the numerical problems. Unlike the tests for the mathematical topics some questions required factual recall of information and so tested attributes other than those of a purely numerical nature. However, for a science subject with a substantially analytic base, the format of the tests was considered quite reasonable by the lecturer and the researchers.

The statistical analysis (analysis of covariance) indicated that nearly 70% of the variance in the first post-test could be "explained" for the topic "Inductive Reactance" and about 60% for the topic "Capacitive Reactance" (the multiple regression analysis gave about 66% and 62% respectively). For "Inductive Reactance" microfiche was significantly better but for "Capacitive Reactance" the two methods were equally effective. A full discussion of this will be given in Section 9.

4 Investigation Using Junior Secondary Mathematics Students

The research reported thus far was with adults, i.e. all subjects were post-secondary students. In order to broaden the scope of the project, an empirical investigation was carried out at the local high school, Woodville High School, with the first year mathematics students as subjects.

The researchers were fortunate in having at their disposal, in co-operation with the secondary teaching staff, a large number of subjects (approximately 230) about whom a great variety of informative data was already available. The data available for each student included, (see Section 10.1):

(a) IQ measured on appropriate scales.
(b) Mathematical ability score measured on a special scale devised by the Senior Mathematics Master at the school and given to all new students enrolling in the first year class at the school.

(c) Reading age score measured on a standardized test of reading ability,
and, at the time of compiling this report
(d) Final year result in the subject.

Consultation with the Senior Mathematics Master led to the decision
to design a programme on the topic "Percentages" for this experiment.
A set of objectives or basic manipulations were set out to be covered
by the programme and the latter were then mapped out in outline by
those involved. Once the final format was agreed upon, bearing in
mind the conceptual level of the students to be tested, the programme
was drawn up by the researchers in co-operation with the senior Math­
ematics Master and processed.

The experimental procedure was basically as described for previous
experiments with some minor changes which will become clear as the
discussion proceeds.

There were four groups identified by colour involved as follows (enrol­
ment figures are those for beginning of the year).

<table>
<thead>
<tr>
<th>Colour</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>75 students</td>
</tr>
<tr>
<td>Blue</td>
<td>58 students</td>
</tr>
<tr>
<td>Green</td>
<td>58 students</td>
</tr>
<tr>
<td>Yellow</td>
<td>75 students</td>
</tr>
</tbody>
</table>

An attempt had been made to make the four colour groups as homogeneous
as possible by ensuring that all were as equivalent as possible on
measures such as intelligence and mathematical ability.

Each colour group received four periods of instruction in mathematics
per week, the time-table being as follows:

<table>
<thead>
<tr>
<th>TIME</th>
<th>MON.</th>
<th>TUE.</th>
<th>WED.</th>
<th>THU.</th>
<th>FRI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 9.00am-10.00am</td>
<td>8Y</td>
<td>8R</td>
<td>8G</td>
<td>8G</td>
<td></td>
</tr>
<tr>
<td>(b) 10.00am-11.00am</td>
<td>8R</td>
<td>8G</td>
<td>8R</td>
<td>8Y</td>
<td></td>
</tr>
<tr>
<td>(c) 11.20am-12.20pm</td>
<td>8G</td>
<td>8B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) 1.15pm- 2.15pm</td>
<td>8Y</td>
<td>(8Y)</td>
<td>8R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) 2.15pm- 3.15pm</td>
<td>8B</td>
<td>8B</td>
<td>(8B)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Classes designed ( ) were held elsewhere than in the regular mathematics area).
7.4 *Investigation Using Junior Secondary Mathematics Students* Contd.

The experimental procedure was as detailed below:

**Week One**: all subjects were given a pre-test (30 minutes) on the topic "Percentages".

**Weeks Two and Three**: were school holiday weeks during which no experiments were carried out at the school, but the final touches were made to the programme. At the end of Week Three, 21 microfiche viewers were set up in the open space unit at the school, the mathematics classrooms being immediately adjacent and separated from the viewer area only by flexible partitions. The viewers were placed on small tables which were arranged in three areas of seven per area.

Precautions were taken to ensure that all machines were carefully focused and set up as it was anticipated that these subjects would require more guidance and supervision in their use than the adults at Kilkenny College of Further Education.

**Week Four**: As each colour group assembled, it was divided into three groups. All subjects had been randomly distributed into three groups which were then checked by the Senior Master to ensure that no one group contained a disproportionate number of very good or poor subjects. A number of students who suffered from severe language difficulties were excluded from the analysis although they were nominally allocated to conventional lectures.

One group then received two lessons from one of their regular classroom teachers on the topic "Percentages", while the other two groups were allowed to work through the programme of the same topic individually on microfiche and booklets respectively, at their own pace, and taking up to 2 lesson periods. As the timetable shows, the 2 lessons or lesson periods were not consecutive. This part of the experiment extended from 9.00 a.m. on Monday until 11.00 a.m. on Wednesday and so the Instructional periods were as follows:

*In the actual situation each colour group consisted of 2 normal class groups, each with its own teacher. One of these teachers took the lesson for the "teacher group" while the other looked after the self-paced booklet group. The Research Officer for the project supervised the microfiche group.*
### 7.4 Investigation Using Junior Secondary Mathematics Students Contd.

The first post-tests were then administered on the Thursday and Friday classes, i.e. as soon as possible after the instructional period.

**Week Five**: The second post-test was administered exactly one week after the administration of the first post-test.

Two features served to distinguish this experiment from those previously described.

1. The subjects using the self-paced methods did, upon request, receive some assistance from the supervisor. The supervisor first of all explained clearly to the subjects how to use either the microfiche machines or the booklets and the importance of carefully following the instructions on each frame. The subjects were then immediately started on the programme so that they would not waste time fiddling with the controls on the machine, changing frames or flipping over the pages of the booklets at random.

The subjects were then allowed to work at their own pace with one subject per machine or per booklet. The majority of students found little difficulty with either medium but some weaker students, who probably would have found any method difficult, received additional assistance to ensure that they progressed steadily through the programme and did not stagnate at any one stage. The supervisors also used the element of praise by commending the subjects who worked steadily through the programme solving all of the problems successfully, e.g. by short phrases such as "good work" or "well done" to students who were observed to obtain correct answers to the problems. Also, some degree of inter-subject interaction was allowed between students at adjacent machines, provided one subject did not simply copy the work of the other, but worked individually through the programme at his own pace.

<table>
<thead>
<tr>
<th>COLOUR GROUP</th>
<th>FIRST INSTRUCTIONAL PERIOD</th>
<th>SECOND INSTRUCTIONAL PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 8R</td>
<td>Tues. 10.00am-11.00am</td>
<td>Wed. 9.00am-10.00am</td>
</tr>
<tr>
<td>(b) 8B</td>
<td>Mon. 2.15pm-3.15pm</td>
<td>Tues. 2.15pm-3.15pm</td>
</tr>
<tr>
<td>(c) 8G</td>
<td>Mon. 11.20am-12.20pm</td>
<td>Wed. 10.00am-11.00am</td>
</tr>
<tr>
<td>(d) 8Y</td>
<td>Mon. 9.00am-10.00am</td>
<td>Tues. 1.15pm-2.15pm</td>
</tr>
</tbody>
</table>

Thus the self-paced subjects were not fully "self-paced" in the sense that the very weak ones were kept moving at least at a slow pace and the two experimental situations (microfiche and booklets) did contain an element of teacher or supervisor interaction with the subjects, especially in the initial stages to get them through the "settling in" stage.

(2) The second feature which distinguished this experiment was the fact that the subjects received some additional formal instruction on the topic between the first and second post-tests. Thus their achievement scores increased significantly between the first and second post-test as well as between the pre-test and the first post-test.

This was necessary in order not to unduly disrupt the school time-table but the second post-test still yielded some interesting results as will be discussed in Section 10.7.1.2, although it was not a "retention test" in the usual sense of the word.

The Research Officer for the research team marked all test papers and they were marked, in most cases, without any knowledge of the groups of the subjects involved.

5 Other Investigations

Excluding the survey investigation, which will be discussed in Sections 11 and 12, further investigations included two small pilot studies conducted during 1976 on completely non-mathematical topics. These were:

(1) "The Chemicals of Life" based upon the South Australian matriculation biology syllabus.

This was undertaken to
(a) find and remove any "bugs" which may appear in the preparation or design of this sort of programme: the actual programme was designed by a senior lecturer attached to one of the adult matriculation centres of the Department of Further Education who had expressed a wish to investigate microfiche self-instructional learning for his own area of specialty (matriculation biology).
7.5 Other Investigations Contd.

(b) determine student response, objective and, via a questionnaire, to a programme on microfiche which contained a great deal of factual information, with most of the problems of the 'multiple choice' variety.

Although only 12 subjects were involved the results were sufficiently encouraging for the work to be pursued during 1977 by the lecturer concerned.

(2) "Animals" based upon the social studies syllabus for primary students (grades 3-4). This programme featured pictures of various indigenous and overseas animals in their natural habitats and was shown to deaf and partially deaf children at Klemzig Speech and Hearing Centre. No attempt was made to gather empirical data from the subjects themselves but the teachers involved were asked for their views regarding the use of microfiche for remedial teaching purposes.

In addition, the following programmes were produced but have not yet been used in experimental trials.

(3) Resistor Colour Coding, A4-sized masters produced in colour fiche to be produced when colour copies become available.

(4) Off-shore navigation, 2 monochrome programmes produced in co-operation with an officer of the S.A. Harbours Board.

These investigations are not discussed in detail in this report as they have been only of a preliminary and preparatory nature. However, their future development and applications will be covered in subsequent publications, either by the authors or by others who continue this work.
Section 5 discussed aspects of the experimental design and some principles underlying the statistical analysis. Sections 6 and 7 respectively discussed the details of the 1975 pilot study and the main investigations carried out during 1976. This Section and the next four will consider the empirical results in detail, discuss what inferences may be drawn from them and, when possible, try to relate them to one another.

This Section will not be concerned with questionnaires or survey data as this is fully discussed in Sections 11 and 12.

1 Preparatory Mathematics Results

The first part of this sub-Section will first briefly consider the general population data and then in the second part discuss collectively the Preparatory Mathematics results obtained with the SPSS ANOVA sub-programme, referring to summary tables.

The third part will discuss the results obtained with the SPSS Regression sub-programme, which was used with the topic "Simultaneous Equations" on the combined first and second term data.

The sample sizes for topics other than "Simultaneous Equations" were far too small for the use of regression analysis and even for this topic the results yielded are indicative rather than definitive.

1 Population Test Data

Table 8-1 shows that for all topics and classes there was a statistically significant increase in test score performance between the Pre-test and Post-test 1. However, there was no significant change between Post-test 1 and Post-test 2.

It will be remembered that whether any t or F value is significant at a given level will depend upon sample size. Thus a very small increase between Pre-test and Post-test 1 will be significant if a sufficient number of subjects is available. The significance levels in Table 8-1 should not therefore be directly compared and care taken not to read too much into the Table. It does show, however, that t23 is substantially less than t12 in most cases. Of course, one would expect a differ-
## TABLE 8-1 POPULATION TEST DATA (PREPARATORY MATHEMATICS)

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRE-TEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>t12 (sign)</th>
<th>t23 (sign)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) ALGEBRAIC</strong></td>
<td>(Marks out of 20 in 20 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUATIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.07</td>
<td>12.18</td>
<td>12.39</td>
<td>3.07 (.01)</td>
<td>1.56 (NS)</td>
</tr>
<tr>
<td>S.D.</td>
<td>4.28</td>
<td>4.18</td>
<td>4.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>18.32</td>
<td>17.40</td>
<td>20.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 42)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>b) SIMULTANEOUS</strong></td>
<td>(Marks out of 10 in 30 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUATIONS - FIRST TERM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.16</td>
<td>3.91</td>
<td>4.36</td>
<td>4.3 (.001)</td>
<td>.86 (NS)</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.05</td>
<td>2.71</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>4.21</td>
<td>7.38</td>
<td>9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 34)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>c) POWERS OF TEN</strong></td>
<td>(Marks out of 20 in 30 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.34</td>
<td>10.36</td>
<td>10.40</td>
<td>8.7 (.001)</td>
<td>.27 (NS)</td>
</tr>
<tr>
<td>S.D.</td>
<td>4.15</td>
<td>4.12</td>
<td>4.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>17.23</td>
<td>16.97</td>
<td>17.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 27)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>d) SIMULTANEOUS</strong></td>
<td>(Marks out of 20 in 30 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUATIONS - FIRST AND SECOND TERM COMBINED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.67</td>
<td>3.41</td>
<td>3.71</td>
<td>6.71 (.001)</td>
<td>.04 (NS)</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.84</td>
<td>2.67</td>
<td>2.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>3.40</td>
<td>7.14</td>
<td>8.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 64)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

1) "NS" means not significant at the 0.05 level for significance for a two-tailed test for dependent samples.  
   t12 is the dependent t test value between Pre-test and Post-test 1.  
   t23 is the dependent t test value between Post-test 1 and Post-test 2.

2) Students had prior knowledge that Post-test 1 would take place immediately after the instructional period but did not know in advance that the Pre-test or Post-test 2 would be given.

3) t12 and t23 are calculated with slightly different populations (groups of subjects) as not all subjects who completed the Pre-test and Post-test 1 sat for the second post-test. All second post-test data refer to subjects who sat for both the other tests.
8.1.1 Population Test Data Contd.

ential reduction in the rate of learning even with regular instruction between the first and second Post-tests. Accordingly, except for "A'gebraic Equations", the Table suggests that there was minimal learning between the two post-tests.

.2 Analysis of Covariance

While the t tests are concerned mainly with differences in means of samples or populations of subjects, analysis of variance or covariance using the SPSS ANOVA sub-programme looks at the variance in one variable, (the dependent variable) such as first or second post-test scores, and as outlined in Section 7, attempts to locate the source of this variance. It calculates the F values for each independent variable, values consisting of the mean square for the independent variable divided by the residual mean squares unaccounted for by all independent variables and then informs the researcher whether the contribution is statistically significant or not for the number of degrees of freedom involved (in the numerator and denominator).

Once again it is important to note that the significance depends on the number of degrees of freedom and so, through the error term, on the total number of subjects. The SPSS ANOVA sub-programme however, also upon request, supplies values of eta, beta and R. These were discussed in Section 7 but briefly eta² gives the fraction of variance in the dependent variable accounted for by factors (categorical independent variables) before the effects of covariates (continuous independent variables) are taken out, beta² the fraction of variance in the adjusted values of the dependent variable accounted for by factors, i.e. after the effects of covariates are taken out, and R² the total fraction of variance in the dependent variable accounted for by all independent variables collectively.

Eta, beta and R are given as part of the Multiple Classification Analysis (MCA) table. If there are more than one factor, the table may also include a beta for each factor after the effect of the other factors have been taken out but before the effects of the
8.1.2 Analysis of Covariance Contd.

covariates are taken out. If there is strong interaction between factors, interpretation of the MCA table, of course, becomes rather involved, but fortunately the ANOVA table enables such interaction effects to be investigated and tested for significance before the MCA table is consulted.

.1 Analysis of Post-test 1

Tables 8-2 (a)(b)(c) summarise the Preparatory Mathematics results obtained using the SPSS ANOVA sub-programme. It tabulates the values of F, the significances of F and the values of eta, beta and multiple R. "Eta" and "beta" here refer to the factors and these are the main concern of this investigation. However, the computer also prints out standardized partial regression coefficients for the covariates upon request. These are not reproduced here as they add only marginally to the discussion. (They are computed at the point where the covariates are entered into the analysis i.e. before factors are entered in the case of the present design).

(a) Method Effects

The immediate observation one can make from a perusal of Tables 8-2(a) and 8-2(b) is that method is making no significant contribution to the variance in the first post-test. In the case of "Simultaneous Equations" however, method did approach significance at the 0.05 level when the first and second term data were combined and both a two-way (using 2 teaching methods - lecture and microfiche) and a three-way (using the lecture, 1 microfiche and books) analysis carried out.

In this case eta^2 squared was \( \approx 0.05 \) for the 2 method situation and \( \approx 0.09 \) for the 3 method situation, indicating that about 5 to 10% of the variance could be accounted for by method if it is processed first, while, in all, about 50% of the variance could be accounted for by all independent variables together.
### TABLE 8-2 (a) ANALYSIS OF POST-TEST 1 (WITH PRE-TEST AS A COVARIATE)

**SIGNIFICANCE OF F VALUES**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>PRE-TEST</th>
<th>INTELL.</th>
<th>AGE</th>
<th>METHOD (M)</th>
<th>TEACHER (T)</th>
<th>M X T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations (1st term)</td>
<td>42</td>
<td>0.001</td>
<td>0.092</td>
<td>0.999</td>
<td>0.999 (5) *</td>
<td>0.999 (3) *</td>
<td>0.999</td>
</tr>
<tr>
<td>2. Simultaneous Equations (1st term)</td>
<td>34</td>
<td>0.001</td>
<td>0.051</td>
<td>0.999</td>
<td>0.999 (5)</td>
<td>0.999 (3)</td>
<td>DNI</td>
</tr>
<tr>
<td>3. Powers of Ten (2nd term)</td>
<td>27</td>
<td>0.001</td>
<td>0.056</td>
<td>0.999</td>
<td>0.999 (2)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4. Powers of Ten (2nd term and 1975 data combined)</td>
<td>40</td>
<td>0.001</td>
<td>0.319</td>
<td>0.999</td>
<td>0.999 (2)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5. Simultaneous Equations (1st &amp; 2nd term data combined)</td>
<td>64</td>
<td>0.001</td>
<td>0.020</td>
<td>0.917</td>
<td>0.070 (3)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>0.001</td>
<td>0.011</td>
<td>0.319</td>
<td>0.084 (2)</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

* Numbers in brackets give numbers of methods or teachers for each experiment.
<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>PRE-TEST</th>
<th>INTELL.</th>
<th>AGE</th>
<th>METHOD (M)</th>
<th>TEACHER (T)</th>
<th>M x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations (1st term)</td>
<td>42</td>
<td>43.846</td>
<td>3.020</td>
<td>0.400</td>
<td>0.175 (5)</td>
<td>0.188 (3)</td>
<td>2.17</td>
</tr>
<tr>
<td>2. Simultaneous Equations (1st term)</td>
<td>34</td>
<td>20.712</td>
<td>4.109</td>
<td>0.018</td>
<td>0.265 (5)</td>
<td>0.424 (3)</td>
<td>DNI</td>
</tr>
<tr>
<td>3. Powers of Ten (2nd term)</td>
<td>27</td>
<td>18.674</td>
<td>3.985</td>
<td>0.058</td>
<td>0.847 (2)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4. Powers of Ten (2nd term and 1975 data combined)</td>
<td>40</td>
<td>43.332</td>
<td>1.027</td>
<td>0.454</td>
<td>0.102 (2)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5. Simultaneous Equations (1st &amp; 2nd term data combined)</td>
<td>64</td>
<td>25.225</td>
<td>5.760</td>
<td>0.011</td>
<td>2.779 (3)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>14.613</td>
<td>7.050</td>
<td>0.750</td>
<td>3.134 (2)</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
### TABLE 8-2 (c) ANALYSIS OF POST-TEST 1 (WITH PRE-TEST AS A COVARIATE)

VALUES OF ETA, BETA AND MULTIPLE R*

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>FACTOR</th>
<th>ETA (adj. for factors plus covariates)</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations (1st term)</td>
<td>Method (5 Methods)</td>
<td>0.19 (0.036)</td>
<td>0.09 (0.008)</td>
</tr>
<tr>
<td></td>
<td>Teacher (3 Teachers)</td>
<td>0.08 (0.006)</td>
<td>0.05 (0.003)</td>
</tr>
<tr>
<td>2. Simultaneous Equations (1st term)</td>
<td>Method (5 Methods)</td>
<td>0.31 (0.096)</td>
<td>0.15 (0.023)</td>
</tr>
<tr>
<td></td>
<td>Teacher (3 Teachers)</td>
<td>0.29 (0.084)</td>
<td>0.14 (0.020)</td>
</tr>
<tr>
<td>3. Powers of Ten (2nd term)</td>
<td>Method (2 Methods)</td>
<td>0.17 (0.029)</td>
<td>0.07 (0.005)</td>
</tr>
<tr>
<td>4. Powers of Ten (2nd term and 1975 data combined)</td>
<td>Method (2 Methods)</td>
<td>0.13 (0.017)</td>
<td>0.03 (0.001)</td>
</tr>
<tr>
<td>5. Simultaneous Equations (1st &amp; 2nd term data combined)</td>
<td>Method (3 Methods)</td>
<td>0.30 (0.090)</td>
<td>0.22 (0.048)</td>
</tr>
<tr>
<td></td>
<td>Method (2 Methods)</td>
<td>0.23 (0.053)</td>
<td>0.19 (0.036)</td>
</tr>
</tbody>
</table>

* Squares of quantities are shown in brackets.
8.1.2.1 (b) **Teacher Effects**

The main purpose for including "teacher" in some runs was to provide a check on the experiment, as intuitively, one would expect all teacher effects to be taken out of the analysis by the Pre-test, which was, in all cases, entered into the analysis before the factors "teacher" and "method". This expectation was confirmed and "teacher" was not significant in the two runs in which it was included in the analysis, its effect being about the same as that of method in these cases.

(c) **Covariate Effects**

The effect of each covariate was that remaining after the other covariates had been entered into the analysis. Thus the effects of the Pre-test, for example, in the present analysis are those remaining after adjustment for intelligence and age.

Hence Pre-test would be expected to exercise an effect both through a subject's prior knowledge of the topic and the subject's intelligence. However, after adjusting for intelligence the effects remaining should reflect prior knowledge (plus extraneous factors due to other uncontrolled variables such as teacher, which have not yet been taken out).

Prior knowledge of the topic, as indicated by the Pre-test after adjustment for intelligence, is seen to be by far the most important covariate being significant to the 0.001 level for each topic.

For several topics intelligence is also a significant covariate especially for "Simultaneous Equations" the most abstract topic, which required a considerable degree of mathematical dexterity whether or not the subjects already had some prior knowledge of it.

Interestingly enough, age was not a significant covariate for any topic, or at least no residual age effects remain-
8.1.2.1 (c) **Covariate Effects Contd.**

The hypothesis that age stratification of groups was warranted is thus apparently not confirmed with this technique, although age could still be correlated with a variety of other pertinent biographical details which affect the error term or residual sum of squares.

(d) **Interaction Effects**

Interaction between factors was insignificant although this could not be directly ascertained for Simultaneous Equations as the computer apparently had the number of combined categories too high for the population size and could not invert the cross-product matrix (hence the designation "ONI") in Table 8-2 (b). For Algebraic Equations the sum of squares for the total main effects was 6.535 and the sums of squares for the individual factors added up to 6.689 suggesting negligible interaction.

With covariates, of course, interaction effects can be quite considerable and we noted, for example, that Pre-test scores, if unadjusted, reflect intelligence as well as prior knowledge of the topic. The total covariate sum of squares will thus tend to be considerably greater than the sum of the individual covariate sum of squares. (The SPSS ANOVA print-out includes the "total" contributions due to all covariates and "total" contributions due to all factors but these are not included in the tables for brevity).

The SPSS ANOVA does not include factor X covariate effects, but, if deemed important, these can be investigated using the SPSS Regression sub-programme (see Section 5.3.3).

---

* It is conceivable that in some circumstances age could become significant after factors are adjusted for as well as covariates. This, however, is unlikely in the present experiment where covariates are accounting for most of the variance in the dependent variable.
8.1.2.2 Analysis of Post-Test 2

(a) Method Effects

On intuitive grounds one certainly would not expect method to be a statistically significant source of variance unless it was also so for Post-test 1. And also, of course, any direct method effects would be taken out of the analysis by Post-test 1 if included as a covariate.

Nevertheless, it was considered worthwhile to analyse the Post-test 2 results in detail and see whether any longer term method effects did, in fact, show up, possibly due to better short-term retention on one method vis-a-vis the others.*

As shown by Table 8-2 (d) no such effects showed up. Even for "Simultaneous Equations" (combined data) for which method effects were approaching significance in the Post-test 1, effects due to method were negligible.

(b) Teacher Effects

With one exception, all Post-tests 2 were administered one week after the first so that no formal instruction was involved during the intervening period. The one exception was "Simultaneous Equations" for the first term class, which has been kept separate for detecting significant effects, "significant" here meaning significant in the real situation, showing up strongly even with the small sample sizes involved.

For "Simultaneous Equations" (first term) there were three formal instructional periods between Post-tests 1 and 2, these being given by the three regular classroom lecturers. This was sufficient for strong teacher effects to show up in the analysis of Post-test 2, F for "teacher" being (8.642), see Table 8-2 (e), nearly as high as that for Intelligence (9.353).

* Long term retention over a number of weeks or months is of course another matter. Several instructional periods and/or topics with the same subjects would probably be necessary to investigate long term retention.
# Table 8-2 (d) Analysis of Post-test 2 (with Post-test 1 as a Covariate)

## Significance of F Values

<table>
<thead>
<tr>
<th>Topic</th>
<th>NO. of Subjects Used in Analysis</th>
<th>Post-test 1</th>
<th>Intell.</th>
<th>Age</th>
<th>Method (M)</th>
<th>Teacher (T)</th>
<th>M × T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations (1st term)</td>
<td>32</td>
<td>0.001</td>
<td>0.999</td>
<td>0.173</td>
<td>0.308 (5)</td>
<td>0.999 (3)</td>
<td>0.999</td>
</tr>
<tr>
<td>2. Simultaneous Equations (1st term)</td>
<td>25</td>
<td>0.001</td>
<td>0.008</td>
<td>0.047</td>
<td>0.286 (5)</td>
<td>0.003 (3)</td>
<td>DNI</td>
</tr>
<tr>
<td>3. Powers of Ten (2nd term)</td>
<td>25</td>
<td>0.001</td>
<td>0.999</td>
<td>0.307</td>
<td>0.999 (2)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4. Simultaneous Equations (1st &amp; 2nd term data combined)</td>
<td>52</td>
<td>0.001</td>
<td>0.323</td>
<td>0.412</td>
<td>0.737 (3)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>0.001</td>
<td>0.697</td>
<td>0.470</td>
<td>0.478 (2)</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
### Table 8-2 (e)  
**Analysis of Post-Test 2 (with Post-Test 1 as a covariate)**  

**Values of $F$**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>POST-TEST 1</th>
<th>INTELL.</th>
<th>AGE</th>
<th>METHOD (M)</th>
<th>TEACHER (T)</th>
<th>M x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations (1st term)</td>
<td>32</td>
<td>48.246</td>
<td>0.519</td>
<td>2.009</td>
<td>1.309 (5)</td>
<td>0.095</td>
<td>0.763</td>
</tr>
<tr>
<td>2. Simultaneous Equations (1st term)</td>
<td>25</td>
<td>77.296</td>
<td>9.353</td>
<td>4.582</td>
<td>1.386 (5)</td>
<td>8.642</td>
<td>DNI</td>
</tr>
<tr>
<td>3. Powers of Ten (2nd term)</td>
<td>25</td>
<td>35.527</td>
<td>0.006</td>
<td>1.101</td>
<td>0.005 (2)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4. Simultaneous Equations (1st &amp; 2nd term data combined)</td>
<td>52</td>
<td>72.558</td>
<td>0.996</td>
<td>0.686</td>
<td>0.307 (3)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>51.455</td>
<td>0.154</td>
<td>0.533</td>
<td>0.514 (2)</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
### TABLE 8-2 (f)  ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)

VALUES OF ETA, BETA AND MULTIPLE R*

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA (adj. for factors plus covariates)</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations</td>
<td>Method (5 Methods)</td>
<td>0.28</td>
<td>0.25</td>
<td>0.874</td>
</tr>
<tr>
<td>(1st term)</td>
<td>Teacher (3 Teachers)</td>
<td>0.25</td>
<td>0.06</td>
<td>0.874</td>
</tr>
<tr>
<td>2. Simultaneous Equations</td>
<td>Method (5 Methods)</td>
<td>0.27</td>
<td>0.23</td>
<td>0.845</td>
</tr>
<tr>
<td>(1st term)</td>
<td>Teacher (3 Teachers)</td>
<td>0.73</td>
<td>0.47</td>
<td>0.845</td>
</tr>
<tr>
<td>3. Powers of Ten (2nd term)</td>
<td>Method (2 Methods)</td>
<td>0.17</td>
<td>0.01</td>
<td>0.870</td>
</tr>
<tr>
<td>4. Simultaneous Equations</td>
<td>Method (3 Methods)</td>
<td>0.29</td>
<td>0.07</td>
<td>0.819</td>
</tr>
<tr>
<td>(1st &amp; 2nd term data combined)</td>
<td>Method (2 Methods)</td>
<td>0.29</td>
<td>0.07</td>
<td>0.819</td>
</tr>
</tbody>
</table>

* Squares of quantities are shown in brackets.
8.1.2.2 (b) Teacher Effects Contd.

Since the analysis is sufficiently sensitive to detect these teacher effects, this gives the researchers added confidence that any significant difference between one instructional mode and another would be detected in Post-test 1, even though the periods of didactic instruction between Post-tests 1 and 2 exceeded the period of experimental instruction prior to Post-test 1.

Investigation of the reason for the relatively poor performance of one teacher revealed that he had emphasized a method of solving linear equations which the subjects had found confusing. This probably would not have shown up except for the experimental investigation and the teacher concerned was able to rectify his approach accordingly.

For "teacher" effects in this case Table 8-2 (f) shows that eta squared is 0.53, i.e. they account for over 50% of the variance in the Post-test 2 if processed before other independent variables.

(c) Covariate Effects

As expected Post-test 1 exerted a strong influence over the variance in Post-test 2 and indeed considerably higher R values were obtained, approaching 0.9 for one topic.

Except for "Simultaneous Equations" (first term) which was seen to be a special case, intelligence was less significant for Post-test 2 than for Post-test 1. Apparently intelligence effects are taken up by the Post-test 1 scores except for "Simultaneous Equations" where the subjects had to apply their mental faculties on several occasions during the intervening period.

Again age was at no time significant with F values well below unity for every topic.

The sample sizes for the Post-test 2 were smaller than those for the Post-test 1 and this should be borne in mind when the two sets of data are compared.
8.1.2.2 (d) **Interaction Effects**

Table 8-2 (d) shows that for 'Algebraic Equations', there is no significant interaction between "teacher" and "method", while for Simultaneous Equations the cross-product matrix could not be inverted, see Section 8.1.2.1 (d).

8.1.3 **Multiple Regression Analysis of Simultaneous Equations Data**

When first and second term "Simultaneous Equations" classes were combined the total population available increased to 64, or to 49 when just microfiche and the lecture groups were considered. Although 4 of these were repeats from first term and so were 'counted twice' it was felt that the one full term between the two experiments was sufficient to render them sufficiently biographically distinct as not to invalidate the statistical procedure.

It was decided to try a multiple regression analysis on the combined group to substantiate, or otherwise, the results obtained with analysis of covariance. As noted previously the regression analysis has poor reliability for small samples in that precisely repeatable results are unlikely; nevertheless, it should give some indication of the contribution of the independent variables to the dependent variable.

The correlation matrix between the variables is shown in Table 8-3 (a).

**Table 8-3 (a)**

**CORRELATION MATRIX FOR "SIMULTANEOUS EQUATIONS" VARIABLES**

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>PRETEST</th>
<th>INTELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>0.230</td>
<td>0.644*</td>
<td>0.552*</td>
</tr>
<tr>
<td>PRETEST</td>
<td>0.02</td>
<td>0.160</td>
<td>0.492*</td>
</tr>
<tr>
<td>INTELL</td>
<td>0.221</td>
<td>0.134</td>
<td>0.231</td>
</tr>
</tbody>
</table>

* Denotes significance at the 0.05 level for a two-tailed test.

We see that neither age nor method are significantly associated with any of the other variables, although Pre-test 1 and Post-test 1 scores and intelligence are all significantly associated.
8.1.3 Multiple Regression Analysis of Simultaneous Equations Data Contd.

D1 does however, account for \((0.230)^2 = 0.053\) of the variance in Post-test 1, which gives a significant result in Table 8-3 (c). Nevertheless, Table 8-3 (b) shows that method becomes insignificant after adjustments are made for Pre-test and Intelligence.

.1 Analysis of Post-test 1

The 'method'dummy variables in the SPSS multiple regression subprogrammes were created by the appropriate control statements:

\[
\text{IF (METHOD EQ 1) D1 = 1 (lecture group)}
\]
\[
\text{IF (METHOD EQ 2) D2 = 1*(microfiche self-paced group)}
\]

and the independent variables processed in a hierarchical order thus, for Post-test 1 score as the dependent variable: Pre-test score, intelligence, age and lastly method (D1, D2 - entered together).

Because the hierarchical approach was used, the variance accounted for by Pre-test is no longer that remaining after the contributions due to other covariates, have been taken out, as in the ANOVA results; rather the maximum amount of variance attributable to Pre-test will be included in the contribution for that variable, i.e. the variance due directly to Pre-test and that due to the other variables acting through Pre-test.

However, because the method variables (D1 and D2) are processed last the variance attributable to them will be that from their direct contribution alone. As this is usually of most interest to the researcher, it is of immediate interest to see whether such direct method effects are significant and this, of course, is also revealed by the ANOVA analysis.

* Strictly only one dummy variable is necessary and so only one IF statement. If we excluded the second IF statement method 2 would become a reference category. However we are not specifying any particular reference category here and the computer will itself exclude one of the dummy variables from the analysis 'because of insufficient tolerance'. Variable D2 is of course completely defined by D1 and vice versa.
8.1.3.1 Analysis of Post-Test 1 Contd.

However the SPSS regression computer print-out also gives the incremental increase in $\Delta R^2$ due to each independent variable as it is added (in the specified order), the F "to enter or remove" for each independent variable, and the "overall F" at each stage and a table of regression coefficients together with the F values for each one as if the relevant variable had been processed last. The significance levels for each F are also included.

A fuller discussion of the statistical principles involved is given in Section 5.3.2.1. Here we will present and interpret the results obtained.

For independent variables entered in the above order, the results can be tabulated as in Table 8-3 (b).

Where $F_1$ is the "F to enter or remove" (as only forward regression is used in this project, this effectively means "F to enter"), $F_2$ indicates the overall significance, $F_3$ is the significance of the additional variance as defined by equation (30) in Section 5.3.2, for a hierarchical procedure, and $F_4$ is the significance of the regression coefficients as if the relevant variable had been added last. $R$ is the multiple correlation coefficient at each step and $r$ the single correlation for each independent variable.

As expected $F_1$, $F_3$ and $F_4$ are all the same for the microfiche method variable D2 as it was processed last.

The direct contribution of method is seen to be approaching significance with the significance level reaching 0.084. As $r$ is negative we conclude that the subjects using microfiche performed somewhat worse than the subjects receiving the lecture in this experiment although the method effect was not significant at the 0.05 level.
### TABLE 8-3 (b)

**Regression Analysis for "Simultaneous Equations"**

**Dependent Variable = Post-Test 1 Score**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRETEST</td>
<td>33.287</td>
<td>0.644</td>
<td>0.415</td>
<td>0.415</td>
<td>0.644</td>
<td>33.287</td>
<td>60.151</td>
<td>15.081</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>INTELLIGENCE</td>
<td>6.536</td>
<td>0.698</td>
<td>0.487</td>
<td>0.073</td>
<td>0.552</td>
<td>21.872</td>
<td>6.804</td>
<td>5.331</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.014)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(S)</td>
<td>(0.026)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AGE</td>
<td>0.715</td>
<td>0.703</td>
<td>0.495</td>
<td>0.008</td>
<td>0.220</td>
<td>14.730</td>
<td>0.749</td>
<td>1.203</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.134)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.279)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D2 (METHOD)</td>
<td>3.134</td>
<td>0.727</td>
<td>0.529</td>
<td>0.034</td>
<td>-0.23051</td>
<td>12.355</td>
<td>3.134</td>
<td>3.134</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.084)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.084)</td>
<td></td>
</tr>
</tbody>
</table>

* adjusted R² = 0.486
8.1.3.1 Analysis of Post-Test 1 Contd.

However the SPSS regression computer print-out also gives the incremental increase in $\Delta R^2$ due to each independent variable as it is added (in the specified order), the $F$ "to enter or remove" for each independent variable, and the "overall $F$" at each stage and a table of regression coefficients together with the $F$ values for each one as if the relevant variable had been processed last. The significance levels for each $F$ are also included.

A fuller discussion of the statistical principles involved is given in Section 5.3.2.1. Here we will present and interpret the results obtained.

For independent variables entered in the above order, the results can be tabulated as in Table 8-3 (b).

Where $F_1$ is the "$F$ to enter or remove" (as only forward regression is used in this project, this effectively means "$F$ to enter"), $F_2$ indicates the overall significance, $F_3$ is the significance of the additional variance as defined by equation (30) in Section 5.3.2, for a hierarchical procedure, and $F_4$ is the significance of the regression coefficients as if the relevant variable had been added last. $R$ is the multiple correlation coefficient at each step and $r$ the single correlation for each independent variable.

As expected $F_1$, $F_3$ and $F_4$ are all the same for the microfiche method variable D2 as it was processed last.

The direct contribution of method is seen to be approaching significance with the significance level reaching 0.084. As $r$ is negative we conclude that the subjects using microfiche performed somewhat worse than the subjects receiving the lecture in this experiment although the method effect was not significant at the 0.05 level.
8.1.3.1 Analysis of Post-Test 1 Contd.

The F3 values are not provided by the SPSS regression print-out and were calculated from the summary Table 8-3 (b) using equation (30) of Section 5.3.2. SS denotes that the value of F3 is significant to the 0.001 level, S that it is significant to the 0.05 level and NS that it was not significant.

Direct method effects are seen to account for 3.4% of the variance in the Post-test 1 or about $0.034 \times 100 = 6.4\%$ of the explained variance.

When the order of entry of the independent variables was altered so that method effects were entered first, the following results shown in Table 8-3 (c) were obtained.

We see that the total effect of method is now just significant at the 0.05 level (taking F3 as our appropriate F ratio). However, the additional effect is only $0.053 - 0.034 = 0.019$ or 1.9% of the variance and, for this size of sample, is hardly worth further investigation. The total method effects account for $0.053 \times 100 = 10\%$ of the explained variance.

As expected, F4 values are the same as for Table 8-3 (b) and the overall F at the final step is also the same in both cases.

How do the above results compare with those obtained using the SPSS ANOVA sub-programme? The results will not be identical, as for the latter sub-programme, the contribution due to each variable was that remaining after the effects of other variables of the same type (covariates or factors) had been taken out, whereas for the SPSS regression sub-programme, F4, which is the appropriate statistic for comparison purposes, measures the contribution of a variable remaining after the effects of all other variables (covariates and factors), had been taken out. However, if we compare the SPSS regression print-out we should have similar results for the covariates and identical results for method which, it will be recalled, was processed last in the former sub-programme.
### TABLE 8-3 (c)  REGRESSION ANALYSIS FOR "SIMULTANEOUS EQUATIONS"

Dependent Variable = Post-test 1 Score

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DI</td>
<td>2.638 (0.111)</td>
<td>0.231</td>
<td>0.053</td>
<td>0.053</td>
<td>0.231</td>
<td>2.637 (0.111)</td>
<td>4.964 (S)</td>
<td>3.134 (0.084)</td>
</tr>
<tr>
<td>2</td>
<td>Pre-test</td>
<td>38.787 (0.001)</td>
<td>0.679</td>
<td>0.461</td>
<td>0.408</td>
<td>0.644</td>
<td>19.660 (0.001)</td>
<td>38.088 (SS)</td>
<td>15.081 (0.001)</td>
</tr>
<tr>
<td>3</td>
<td>Intelligence</td>
<td>5.140 (0.028)</td>
<td>0.718</td>
<td>0.516</td>
<td>0.055</td>
<td>0.552</td>
<td>15.800 (0.001)</td>
<td>5.163 (S)</td>
<td>5.331 (0.026)</td>
</tr>
<tr>
<td>4</td>
<td>Age</td>
<td>1.203 (0.279)</td>
<td>0.727</td>
<td>0.529</td>
<td>0.013</td>
<td>0.221</td>
<td>12.355 (0.001)</td>
<td>1.203 (NS)</td>
<td>1.203 (0.279)</td>
</tr>
</tbody>
</table>

* Adj. R² = 0.486
8.1.3.1 Analysis of Post-Test 1 Contd.

TABLE 8-3 (d)

COMPARISON OF SPSS ANOVA AND SPSS REGRESSION RESULTS FOR POST-TEST 1 (SIMULTANEOUS EQUATIONS)

F VALUES

<table>
<thead>
<tr>
<th>INDEPENDENT</th>
<th>ANOVA FROM TABLES 8-2(a) &amp; 8-2(b)</th>
<th>REGRESSION (F4) FROM TABLE 8-3(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-TEST</td>
<td>14.613 (SS)</td>
<td>15.081 (SS)</td>
</tr>
<tr>
<td>INTELLIGENCE</td>
<td>7.050 ($)</td>
<td>5.331 ($)</td>
</tr>
<tr>
<td>AGE</td>
<td>0.750 (NS)</td>
<td>1.203 (NS)</td>
</tr>
<tr>
<td>METHOD</td>
<td>3.134 (NS)</td>
<td>3.134 (NS)</td>
</tr>
</tbody>
</table>

Comparing $R^2$ and eta$^2$ values for total method effects, we get identical results from Tables 8-2(c) and 8-3(b), i.e. from the ANOVA and multiple regression analyses respectively. $R^2$ is 0.529 and eta$^2$ is 0.053.

Thus we see that the two approaches yield very similar results but the SPSS regression sub-programme contains much more information and, if required, enables research to be pursued to a much greater depth (for a full discussion of possibilities, see Nie et al, and Kerlinger and Padhazur (134)(135)).

The multiple regression analysis for Post-test 2 is not discussed as the number of subjects per method (about 20) is too small to warrant discussion. Relevant discussion based upon the ANOVA results was given previously (in Section 8.1.2.2). Of course, even for the Post-test 1 the figures cited, as has been stressed several times, are only indicative.

2 Analysis of Time Taken by Self-Paced Subjects on "Simultaneous Equations".

In the last section we only included the lecture and microfiche self-paced subjects in the analysis. It is a worthwhile exer-
8.1.3.2 Analysis of Time Taken by Self-Paced Subjects on "Simultaneous Equations" Contd.

close to look at the 15 booklet self-paced subjects and the microfiche self-paced subjects together, to see whether the time taken on the lesson can be related to other variables under our control.

The term "self-paced" usually means that the subject works at his own speed so that the time taken is not a significant or major variable in determining performance on Post-test 1, administered immediately afterwards. Brighter subjects with considerable prior-knowledge of the topic will finish the programme sooner than the other subjects but, when intelligence and Pre-test scores are allowed for or "controlled", time should fade out as a significant predictor or covariate.

Table 8-3 (e) shows the single correlation matrix between time taken TT, and other relevant variables.

**TABLE 8-3 (e)**

**CORRELATION MATRIX FOR "SIMULTANEOUS EQUATIONS" SELF-PACED SUBJECTS**

\[ N = 42 \]

<table>
<thead>
<tr>
<th></th>
<th>D2**</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>TT</th>
<th>POST TEST 1</th>
<th>D2</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2**</td>
<td>0.173</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRETEST</td>
<td>0.707*</td>
<td>0.150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTELL</td>
<td>0.422*</td>
<td>-0.090</td>
<td>0.432*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>-0.091</td>
<td>-0.120</td>
<td>0.084</td>
<td>-0.134</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TT</td>
<td>-0.567*</td>
<td>0.034</td>
<td>-0.534*</td>
<td>-0.439*</td>
<td>0.264</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* denotes significance at the 0.05 level for a two-tailed test.

** D2 denotes the microfiche self-paced group. The other teaching situation is self-paced instruction using booklets. No lecture, of course, was involved in the present analysis.

We see that the brighter subjects who scored well on the Pre-test worked through the programme in a shorter time than other subjects. We see also that TT or "time taken" accounts for \((-0.567)^2\) or 0.321 of the variance in Post-test 1. However, our analysis will show that after Pre-test, intelligence and age are adjusted for, the variance accounted for by TT drops back to only a few percent (Table 8-3 (f)).

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8.1.3.2 Analysis of Time Taken by Self-Paced Subjects on "Simultaneous Equations" Contd.

TT has very little association with O2. Subjects worked through both forms of self-paced instruction at about the same speed assuming that they all finished the programme.

The hierarchical method of multiple regression analysis provides an excellent way to check this hypothesis by firstly processing the variables so that time taken is processed after all other independent variables. With 42 self-paced students together it was felt that a multiple regression analysis should yield some useful information and be a worthwhile exercise. A back-up analysis was also carried out using the ANOVA sub-programme.

Tables 8-3 (e) and 8-3 (f) respectively summarize the results obtained with time taken (designated "TT") processed last and then first in the hierarchical procedure.

We see that time taken is not significant when the other variables are controlled for and its direct influence only accounts for about 3% of the variance in Post-test 1 scores. But when we process time taken first, so as to measure its total effect, it accounts for 32% of the variance, more than any other independent variable.

We conclude that time taken is not an important variable once allowance is made for Pre-test score and intelligence. There is a slight effect which indicates that the slower subjects do not do quite as well as faster subjects, after Pre-test score and intelligence are allowed for, but this is not significant at the 0.05 level.

Not much credence can be placed on the values for the method variable (O2) in Tables 8-3 (f) and 8-3 (g), of course, as only 15 subjects used one of the self-paced methods, a far too small sample size for this sort of analysis.

Table 8-3 (h) compares results with those obtained by the SPSS ANOVA sub-programme.

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TABLE 8-3 (f)  
REGRESSION ANALYSIS FOR SELF-PACED STUDENTS  
TOPIC: "SIMULTANEOUS EQUATIONS"

DEPENDENT VARIABLE = POST-TEST 1 SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRETEST</td>
<td>39.675</td>
<td>0.707</td>
<td>0.499</td>
<td>0.499</td>
<td>0.707</td>
<td>39.875</td>
<td>17.964</td>
<td>13.151</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL.</td>
<td>1.342</td>
<td>0.718</td>
<td>0.516</td>
<td>0.017</td>
<td>0.422</td>
<td>20.779</td>
<td>1.420</td>
<td>0.517</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.254)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.477)</td>
</tr>
<tr>
<td>3</td>
<td>AGE</td>
<td>1.350</td>
<td>0.730</td>
<td>0.532</td>
<td>0.017</td>
<td>-0.091</td>
<td>14.427</td>
<td>1.420</td>
<td>0.162</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.253)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.690)</td>
</tr>
<tr>
<td>4</td>
<td>D2 (METHOD)</td>
<td>0.353</td>
<td>0.733</td>
<td>0.537</td>
<td>0.005</td>
<td>0.173</td>
<td>10.746</td>
<td>0.418</td>
<td>0.803</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.534)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.376)</td>
</tr>
<tr>
<td>5</td>
<td>TT</td>
<td>2.617</td>
<td>0.754</td>
<td>0.569</td>
<td>0.031</td>
<td>-0.567</td>
<td>9.496</td>
<td>2.617</td>
<td>2.617</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.114)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.114)</td>
</tr>
</tbody>
</table>

* Adjusted $R^2 = 0.509$
**TABLE 8-3 (g) REGRESSION ANALYSIS FOR SELF-PACED STUDENTS**

DEPENDENT VARIABLE = POST-TEST SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F²</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TT</td>
<td>16.991 (0.000)</td>
<td>0.567</td>
<td>0.322</td>
<td>0.322</td>
<td>-0.567</td>
<td>18.991 (0.000)</td>
<td>26.896 (SS)</td>
<td>2.617 (0.114)</td>
</tr>
<tr>
<td>2</td>
<td>PRETEST</td>
<td>19.726 (0.000)</td>
<td>0.741</td>
<td>0.550</td>
<td>0.228</td>
<td>0.707</td>
<td>23.804 (0.000)</td>
<td>19.044 (SS)</td>
<td>13.151 (0.001)</td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>0.422 (0.520)</td>
<td>0.745</td>
<td>0.555</td>
<td>0.005</td>
<td>0.422</td>
<td>15.775 (0.000)</td>
<td>0.418 (NS)</td>
<td>0.517 (0.477)</td>
</tr>
<tr>
<td>4</td>
<td>Age</td>
<td>0.377 (0.543)</td>
<td>0.748</td>
<td>0.559</td>
<td>0.004</td>
<td>-0.091</td>
<td>11.731 (0.000)</td>
<td>0.334 (NS)</td>
<td>0.162 (0.690)</td>
</tr>
<tr>
<td>5</td>
<td>D2</td>
<td>0.803 (0.376)</td>
<td>0.754</td>
<td>0.569*</td>
<td>0.010</td>
<td>0.173</td>
<td>9.496 (0.000)</td>
<td>0.803 (NS)</td>
<td>0.803 (0.376)</td>
</tr>
</tbody>
</table>

* Adjusted R² = 0.509
8.1.3.2 Analysis of Time Taken by Self-Paced Subjects on "Simultaneous Equations" Contd.

TABLE 8-3 (h)
FOR SPSS COMPARISON OF F VALUES ANOVA BY REGRESSION SUB-PROGRAMMES

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLE</th>
<th>ANOVA</th>
<th>REGRESSION (F&lt;sub&gt;4&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRETEST</td>
<td>16.376 (SS)</td>
<td>13.151 (SS)</td>
</tr>
<tr>
<td>INTELLIGENCE</td>
<td>0.334 (NS)</td>
<td>0.517 (NS)</td>
</tr>
<tr>
<td>AGE</td>
<td>0.375 (NS)</td>
<td>0.162 (NS)</td>
</tr>
<tr>
<td>METHOD</td>
<td>0.803 (NS)</td>
<td>0.803 (NS)</td>
</tr>
<tr>
<td>TT</td>
<td>2.225 (NS)</td>
<td>2.617 (NS)</td>
</tr>
<tr>
<td>R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.569</td>
<td>0.569</td>
</tr>
</tbody>
</table>

Again the results are the same, bearing in mind the slight difference in the processing of the variables discussed in the last sub-section.

An ANOVA carried out on the Post-test 2 found that F for TT had dropped even further, to 0.081, for the self-paced students, what slight effects it exercised in Post-test 1 having been taken out when the latter was used as the principal covariate in the analysis.

Alternatively TT would have been analyzed directly as a dependent variable but the above procedure has the merit of showing more directly the relationship between TT and performance on objective achievement tests.
8.1.4 Comparison of Instructional Durations

It is informative to look at the times taken by students using self-paced learning in comparison with the durations of the lecture periods.

In the last sub-section we saw that time taken (TT) on self-paced learning probably has little direct effect on Post-test 1 scores. Thus any significant variance in TT means that there is a significant saving in time for the more able subjects, while, for others, there is an opportunity to spend a greater time on given topics.

For the lecture situation therefore, under the same conditions, one or both categories will not be catered for. Either the able subjects spend too much time on the topic or the less able subjects insufficient time. This will not show up in Post-test 1 scores unless the time taken by the lecture is too short to be compensated for by the weaker subjects having to work harder to keep up with the flow of information. As the lecture situation is different from the self-paced situation, one cannot readily extrapolate from one to the other and say that slow students in the former situation will in fact learn less than in the latter. "Working at one's own pace" does not necessarily mean that one cannot work at another pace within certain limits, if required.

Table 8-4 compares the Instructional times for the various topics. In the Table, no distinction is drawn between subjects who worked as individuals or as small groups on booklets and microfiche.

The Table shows that there was no great overall difference between the mean times spent by the groups undertaking self-paced instruction and those receiving conventional teaching. Thus the lecturers were successfully aiming at about the mean range of abilities in their classes. Of interest also are the quite considerable standard deviations of the self-paced groups ranging from a third to over two-thirds of the mean times taken.
### 8.1.4 Comparison of Instructional Durations Contd.

**TABLE 8-4**

**COMPARISON OF INSTRUCTIONAL DURATIONS (MINUTES)**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>MICROFICHE</th>
<th>EBOOKLETS</th>
<th>LECTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algebraic Equations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>29.2</td>
<td>28.2</td>
<td>33.0 (fixed)</td>
</tr>
<tr>
<td>S.D.</td>
<td>20.9</td>
<td>14.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Variance</td>
<td>436.4</td>
<td>211.9</td>
<td>0.0</td>
</tr>
<tr>
<td>2. Simultaneous Equations (First term only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>40.9</td>
<td>44.4</td>
<td>60.0 (fixed)</td>
</tr>
<tr>
<td>S.D.</td>
<td>17.5</td>
<td>16.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Variance</td>
<td>306.7</td>
<td>283.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3. Powers of Ten (Second term only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>40.2</td>
<td>NO</td>
<td>37.0 (fixed)</td>
</tr>
<tr>
<td>S.D.</td>
<td>13.48</td>
<td>BOOKS</td>
<td>0.0</td>
</tr>
<tr>
<td>Variance</td>
<td>181.72</td>
<td>USED</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### 2. Stage 1 Mathematics Results

Here two topics were used in the investigation, "Vectors" and "Complex Numbers." The former experiment was carried out in first term with full-time students and the full repertoire of five teaching methods described in Section 7. "Complex Numbers" was first used as a topic with the same full-time students at the beginning of second term, with the repertoire of teaching methods reduced to three. Finally, "Complex Numbers" was used as a topic with part-time students using only two teaching methods, the lecture and individuals using self-paced learning with microfiche.
### 8.2.1 Population Test Data

Table 8-5 shows population test data for the three experiments.

#### TABLE 8-5

**POPULATION TEST DATA FOR STAGE 1 MATHEMATICS**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>t12 (SIGN.)</th>
<th>t23 (SIGN.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vectors (Marks out of 10 in 30 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>5.19</td>
<td>7.27</td>
<td>7.21</td>
<td>3.7</td>
<td>0.0</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.00</td>
<td>1.96</td>
<td>1.91</td>
<td>(0.01)</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>4.00</td>
<td>3.84</td>
<td>3.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 34)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Complex Numbers - Full-time (Marks out of 10 in 30 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.90</td>
<td>6.09</td>
<td>6.67</td>
<td>8.9</td>
<td>1.9</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.28</td>
<td>1.84</td>
<td>1.65</td>
<td>(0.001)</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>5.20</td>
<td>3.41</td>
<td>2.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Complex Numbers - Part-time &amp; Full-time combined. (Marks out of 10 in 30 minutes maximum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.80</td>
<td>6.35</td>
<td>6.19</td>
<td>18.9</td>
<td>0.54</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.06</td>
<td>1.51</td>
<td>1.85</td>
<td>(0.001)</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>4.25</td>
<td>2.28</td>
<td>3.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 68)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Table 8-5 the combined data for Complex Numbers is that for subjects who completed all three tests. For the full-time students, Complex Numbers and Vectors t12 and t23 are calculated for slightly different populations as not all subjects who sat for the Pre-test and Post-test 1 also sat for the Post-test 2.

Again we see that t12 is much greater than t23 in each case, indicating that most learning, as measured by our tests, occurred during the instructional period and not between Post-tests 1 and 2.

2. **Analysis of Covariance**

Discussions of this are given in sub-sections 5.3.1 and 8.1.2, so we can enter immediately into a discussion of Post-test 1 results.
8.2.2.1 Analysis of Post-test 1

Table 8-6 (a) summarizes the Stage 1 mathematics Post-test 1 results obtained using the SPSS ANOVA sub-programme.

(a) Method Effects

Once again method is not significant for any topic and the subjects gained information as readily by one method as by another. There is some suggestion that the Vectors and combined (part-time and full-time) Complex Numbers subjects tended to perform slightly better using self-paced methods than those receiving conventional lecture instruction and vice-versa for the full-time Complex Numbers subjects. However, these trends are far from significant and, for the small population topics (topics 1 and 2) are probably a result of group rather than method effects (see sub-section 8.2.1).

For topic 3 $\eta^2$ is nearly zero but $R^2$ has also fallen due to the introduction of more extraneous variance with the combination of full-time and part-time data.

(b) Teacher Effects

The full-time subjects in the lecture group received instruction from only one teacher and so teacher was not a relevant variable for topics 1 and 2, i.e. no effects of different teachers are possible.

However, part-time subjects, as described in Section 8.2.2, did have two regular lecturers and were in two classes. Thus when we pool data from full-time and part-time subjects we have a well defined teacher variable with three different lecturers.

In the analysis each subject was allocated a teacher variable according to the following rule:

<table>
<thead>
<tr>
<th>TEACHER</th>
<th>VALUE OF TEACHER VARIABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time subjects' teacher</td>
<td>1</td>
</tr>
<tr>
<td>Part-time subjects' teacher A</td>
<td>2</td>
</tr>
<tr>
<td>Part-time subjects' teacher B</td>
<td>3</td>
</tr>
</tbody>
</table>
### TABLE 8-6 (a)

**ANALYSIS OF POST-TEST I (WITH PRE-TEST AS A COVARIATE)**

**SIGNIFICANCE OF F VALUES**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>PRE-TEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>METHOD (M)*</th>
<th>TEACHER (T)</th>
<th>M x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VECTORS (Full-time)</td>
<td>34</td>
<td>0.001</td>
<td>0.002</td>
<td>0.002</td>
<td>0.295 (5)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. COMPLEX NUMBERS (Full-time)</td>
<td>29</td>
<td>0.002</td>
<td>0.030</td>
<td>0.999</td>
<td>0.333 (3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. COMPLEX NUMBERS (Full and part-time combined)</td>
<td>81</td>
<td>0.001</td>
<td>0.003</td>
<td>0.999</td>
<td>0.254 (2)</td>
<td>0.999 (3)</td>
<td>0.206</td>
</tr>
</tbody>
</table>

* The figures in brackets indicate the number of methods used.
8.2.2.1 (b) Teacher Effects Contd.

Thus the "teacher variable" actually measures "class" or regular classroom lecturer. As not all subjects received conventional instruction during the experiment, it does not indicate the "teacher who gave instruction" in all cases. We would expect such teacher effects to be taken out by the Pre-test so that teacher would not be a significant variable in determining Post-test 1 scores and this expectation was confirmed, with $\eta^2$ only 0.004 and $F$ only about 0.55, (Tables 8-6 (c) and Table 8-6 (b) respectively).

(c) Covariate Effects

For abstract topics such as these one would expect that prior-knowledge of the topic and intelligence to be important predictors of performance on the Post-test 1. Table 8-6 (a) shows that these variables are both significant at the 0.05 level.

Age is a quite significant covariate for the Vectors topic. The standardized partial regression coefficient (not given here) for age is negative, suggesting that the older students found it more difficult to grasp abstract concepts during the instructional period for this topic irrespective of teaching method. Age stratification may therefore have been a justifiable group selection procedure for this topic.

(d) Interaction Effects

These we only considered for topic 3 where two factors were considered. Table 8-6 (a) shows that the method x teacher effects were negligible as one would expect.

.2 Analysis of Post-test 2

Relevant results are summarized in Tables 8-6 (d)(e)(f).

(a) Method Effects

Once again method is not significant in any case after adjustments for covariates and other factors with a significance level of only 0.999, see Table 8-6 (d), a not unexpected result (see discussion in 8.1.2.2 (a)).
## TABLE 8-6 (b)

**ANALYSIS OF POST-TEST 1 (WITH PRE-TEST AS A COVARIATE)**

**VALUES OF $F$**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>PRE-TEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>METHOD (M)*</th>
<th>TEACHER (T)</th>
<th>M x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VECTORS</td>
<td>34</td>
<td>21.240</td>
<td>11.773</td>
<td>5.851</td>
<td>1.301 (5)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Full-time)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. COMPLEX NUMBERS</td>
<td>29</td>
<td>12.192</td>
<td>5.226</td>
<td>0.430</td>
<td>1.156 (3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Full-time)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. COMPLEX NUMBERS</td>
<td>81</td>
<td>19.764</td>
<td>9.781</td>
<td>0.318</td>
<td>1.313 (2)</td>
<td>0.554 (3)</td>
<td>1.608</td>
</tr>
<tr>
<td>(Full and part-time combined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The figures in brackets indicate the number of methods used.
TABLE 8-6 (c)

ANALYSIS OF POST-TEST 1 (WITH PRE-TEST AS A COVARIATE)

VALUES OF ETA, BETA AND MULTIPLE R*

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VECTORS (Full-time)</td>
<td>METHOD</td>
<td>0.50</td>
<td>0.27</td>
<td>0.814</td>
</tr>
<tr>
<td></td>
<td>(5 methods)</td>
<td>(0.250)</td>
<td>(0.073)</td>
<td>(0.663)</td>
</tr>
<tr>
<td>2. COMPLEX NUMBERS (Full-time)</td>
<td>METHOD</td>
<td>0.32</td>
<td>0.23</td>
<td>0.716</td>
</tr>
<tr>
<td></td>
<td>(3 methods)</td>
<td>(0.102)</td>
<td>(0.053)</td>
<td>(0.512)</td>
</tr>
<tr>
<td>3. COMPLEX NUMBERS (Full and part-time combined)</td>
<td>METHOD</td>
<td>0.01</td>
<td>0.11</td>
<td>0.556</td>
</tr>
<tr>
<td></td>
<td>(2 methods)</td>
<td>(0.000)</td>
<td>(0.012)</td>
<td>(0.310)</td>
</tr>
<tr>
<td></td>
<td>TEACHER</td>
<td>0.06</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3 teachers)</td>
<td>(0.004)</td>
<td>(0.012)</td>
<td></td>
</tr>
</tbody>
</table>

* squares of quantities are shown in brackets.
TABLE 8-6 (d)

ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)

SIGNIFICANCE OF F VALUES

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>FIRST TEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>METHOD (M)</th>
<th>TEACHER (T)</th>
<th>M X T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VECTORS (Full-time)</td>
<td>32</td>
<td>0.001</td>
<td>0.116</td>
<td>0.006</td>
<td>0.999</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. COMPLEX NUMBERS</td>
<td>24</td>
<td>0.002</td>
<td>0.087</td>
<td>0.999</td>
<td>0.999</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. COMPLEX NUMBERS</td>
<td>75</td>
<td>0.001</td>
<td>0.999</td>
<td>0.999</td>
<td>0.999</td>
<td>0.017</td>
<td>0.999</td>
</tr>
</tbody>
</table>
### TABLE 8-6 (e)

**ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)**

**F VALUES**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>NO. OF SUBJECTS USED IN ANALYSIS</th>
<th>FIRST POST-TEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>METHOD (M)</th>
<th>TEACHER (T)</th>
<th>M x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VECTORS (Full-time)</td>
<td>32</td>
<td>77.382</td>
<td>2.611</td>
<td>9.024</td>
<td>0.637</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. COMPLEX NUMBERS (Full-time)</td>
<td>24</td>
<td>13.383</td>
<td>3.197</td>
<td>0.390</td>
<td>0.587</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. COMPLEX NUMBERS (Full and part-time combined)</td>
<td>75</td>
<td>26.306</td>
<td>0.472</td>
<td>0.938</td>
<td>0.001</td>
<td>4.326</td>
<td>0.306</td>
</tr>
</tbody>
</table>
**TABLE 8-6 (f)**

**ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)**

**VALUES OF ETA, BETA AND MULTIPLE R**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VECTORS (Full-time)</td>
<td>METHOD</td>
<td>0.52</td>
<td>0.17</td>
<td>0.896</td>
</tr>
<tr>
<td></td>
<td>(5 methods)</td>
<td>(0.270)</td>
<td>(0.029)</td>
<td>(0.803)</td>
</tr>
<tr>
<td>2. COMPLEX NUMBERS (Full-time)</td>
<td>METHOD</td>
<td>0.30</td>
<td>0.17</td>
<td>0.767</td>
</tr>
<tr>
<td></td>
<td>(3 methods)</td>
<td>(0.090)</td>
<td>(0.029)</td>
<td>(0.588)</td>
</tr>
<tr>
<td>3. COMPLEX NUMBERS (Full and part-time combined)</td>
<td>METHOD</td>
<td>0.01</td>
<td>0.00</td>
<td>0.617</td>
</tr>
<tr>
<td></td>
<td>(2 methods)</td>
<td>(0.00)</td>
<td>(0.000)</td>
<td>(0.381)</td>
</tr>
<tr>
<td></td>
<td>TEACHER</td>
<td>0.32</td>
<td>0.31</td>
<td>(0.102)</td>
</tr>
<tr>
<td></td>
<td>(3 teachers)</td>
<td>(0.096)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Squares of quantities are shown in brackets.
8.2.2.2 (b) Teacher Effects

"Teacher" did show up as a significant factor for topic 3. An examination of the MCA Table 8-6 (f) revealed that "teacher 3" was more successful than "teachers 1 and 2". As all were competent lecturers this may seem strange until it is realized that the "teacher 3" subjects were the full-timers while the others were part-timers.

The full-timers had already participated in the experiment for the topic "Vectors" and knew there would be a Post-test 2 very similar in form to the first, whereas the part-timers did not have the advantage of such prior knowledge. Thus the full-timers possibly worked or revised the topic between Post-tests 1 and 2 whereas the part-timers, most of whom had full-time jobs elsewhere during the day, appeared not to do so, at least not so conscientiously. Thus "Teacher Effects" show up sufficiently to reach significance at the 0.05 level with an $R^2$ value of only 0.381.

(c) Covariate Effects

Table 8-6 (a) shows that while Post-test 1 score is very significant, as expected, intelligence had tended to fade out of the picture as a direct source of variance. Most intelligence effects are thus indirect acting through Post-test 1. For topic 2 intelligence is approaching significance, however, and the standardized regression coefficient (not shown) is positive indicating that the more intelligent subjects perform marginally better, as one would expect.

Again comes through strongly for Post-test 2 topic 1 but it is now the older subjects who are performing better. One explanation could be that the older full-time subjects, having performed relatively poorly in Post-test 1, worked harder between Post-tests 1 and 2 to "catch up" but this is, of course, conjecture. It would require a much larger sample than 32 and possibly a multiple regression analysis.
8.2.2.2 (c) **Covariate Effects Contd.**

to gauge the validity of such assertions. Age was having very little effect for the other topics.

(d) **Interaction Effects**

Again method x teacher effects had no effects with a significance of F value of 0.999.

8.2.3 **Some Graphical Representations of Complex Numbers Data**

Before proceeding further and discussing the results of a multiple regression analysis carried out on the Complex Numbers data, it is informative to present some of the data on simple graphs. Such graphical representations have the advantage of being immediately meaningful even to the reader with no statistical training or expertise but, on the other hand, they are only "gross representations" or "average data" and are no substitute for a proper analysis taking all of the data into account.

Although 88 subjects were involved in the experiment involving Complex Numbers (full and part-time) it was unfortunately impossible to ensure that all students sat for every test and complete sets of test data were only obtained for 36 of the lecture group and 32 of the fiche group. The data are shown in Figure 8-1.

While the mean score of the fiche group is somewhat lower on the Pre-test than that of the lecture group, a t-test for independent samples shows the difference not to be significant at the 0.05 level due to the large standard deviations of the scores. Both groups, however, significantly increased their performance during the Instructional period, confirmed by a t-test for dependent samples which shows this to be significant at the 0.001 level for each group.

Similarly, the mean scores for both groups on Post-test 2 were not significantly different either from each other or from the scores on Post-test 1.

Figure 8-2 shows the effects of intelligence, each group being split up into higher and lower intelligence sub-groups for comparison purposes, the dichotomization being carried out using the mean IQ of all subjects as a common reference. As this procedure consid-

See also (136).
Graphical Representation of Student Performances

<table>
<thead>
<tr>
<th>Method</th>
<th>Pretest</th>
<th>Posttest 1</th>
<th>Posttest 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lecture</td>
<td>Mean</td>
<td>2.24</td>
<td>6.28</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.45</td>
<td>1.63</td>
</tr>
<tr>
<td></td>
<td>(N=36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lecture</td>
<td>Mean</td>
<td>1.31</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.43</td>
<td>1.47</td>
</tr>
<tr>
<td></td>
<td>(N=32)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Fig. 8-2**
**GRAPHICAL REPRESENTATION OF STUDENT PERFORMANCES**

**TEST SCORE**
(ranks out of 10)

<table>
<thead>
<tr>
<th>Method</th>
<th>Subgroup</th>
<th>Mean IQ</th>
<th>S.D. of IQ Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lecture</strong></td>
<td>IQ &gt; mean of population</td>
<td>122.8 (N=20)</td>
<td>5.61</td>
</tr>
<tr>
<td></td>
<td>IQ &lt; mean of population</td>
<td>108.5 (N=21)</td>
<td>6.67</td>
</tr>
<tr>
<td><strong>Lecture</strong></td>
<td>IQ &gt; mean of population</td>
<td>122.4 (N=17)</td>
<td>4.51</td>
</tr>
<tr>
<td></td>
<td>IQ &lt; mean of population</td>
<td>108.4 (N=23)</td>
<td>4.88</td>
</tr>
</tbody>
</table>
8.2.3 Some Graphical Representations of Complex Numbers Data Contd.

erably reduces all frequencies, the initial part of the figure (between Pre-test and Post-test 1) utilizes all 81 subjects who completed both Pre-test and Post-test 1. The second part of the figure (between Post-tests 1 and 2) is less reliable as it only uses the 68 subjects who sat for all tests reducing the average cell frequency to only 17.

Figure 8-2 suggests that differences in mean scores between the sub-groups on the Post-test 1 are due mainly to differences in intelligence and associated variables and not due to differences in method. In fact with intelligence as a covariate it suggests that Pre-test may not even be necessary for this topic!

Figure 8-3 shows the effects of age. In this case the result is the same whether the mean age of all the subjects is used as a common reference or the mean age of each training group is used as the reference for that group. The figure indicates that age has little or no effect on the Post-test scores.

The above figures (8-1 to 8-3) are presented for simplicity but the general results obtained by such methods should be checked using more elaborate procedures. We have already discussed results obtained using the SPSS ANOVA sub-programme and we will now discuss the results obtained using the SPSS REGRESSION sub-programme.

4 Multiple Regression Analysis of Complex Numbers Data

For this analysis the population used consisted of the 36 lecture-group and 32 microfiche-group subjects who sat for all three tests. This reduced the number of subjects available but avoided complications arising from "missing data", which apparently has still not been fully sorted out with the SPSS REGRESSION sub-programme, and enabled the analysis of Post-test 2 to proceed using the same subjects as for the analysis of Post-test 1.

68 subjects was deemed a sufficient number for a multiple regression analysis although the reliability or reproducibility of individual statistics is somewhat dubious as has been stressed several times, e.g. see Sections 5.3.2 and 8.1.3.
Multiple Regression Analysis of Complex Numbers Data Contd.

Table 8-7 shows the correlation matrix. The simple correlation between D1 and the other variables is in all cases small except between D1 and Pre-test where it is 0.226, still not significant at the 0.05 level. As we noted previously (Figure 8-1), the microfiche-group performed slightly worse than the lecture-group on the Pre-test.

Intelligence has little correlation with Pre-test scores for this subject but is significantly, although not heavily, correlated with the Post-test 1 and Post-test 2 scores. On the other hand, Pre-test, Post-test 1 and Post-test 2 are all well correlated so that Pre-test scores and intelligence are apparently near-independent determinants of Post-test 1 and Post-test 2 scores.

Subsequent analyses will show that method makes very little contribution to the Post-test 1 and Post-test 2 (and TPTS) scores before or after Pre-test and intelligence are adjusted for.

1 Analysis of Post-test 1

Because of the relative lack of control over extraneous variables it was only possible to account for about 32% of the variance in Post-test 1 and about 37% of the variance in Post-test 2. However, with the larger number of subjects significant results could be obtained, and hence high sensitivity with smaller values in \( R^2 \) and \( \Delta R^2 \) than before. Following a procedure similar to that used for "Simultaneous Equations", in sub-Section 8.1.3.1 we will enter the independent variables in sequence.

Pre-test 
Intelligence 
Age 
D3 to D5 together ("teacher" variables) 
D1 and D2 together ("method" variables) 

and then in the sequence

D1 and D2 together 
Pre-test 
Intelligence 
Age 
D3 to D5 together 

and see what conclusions we can draw from the results thus obtained.
### Table 6.7

**Correlation Matrix for Complex Numbers**

<table>
<thead>
<tr>
<th></th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>TIPS</th>
<th>N.D.</th>
<th>N.C.</th>
<th>DIFF</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>INTELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-TEST 1</td>
<td>0.380*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST-TEST 2</td>
<td>0.453*</td>
<td>0.335*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIPS</td>
<td>0.458*</td>
<td>N.D.*</td>
<td>N.C.*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td>0.126</td>
<td>0.046</td>
<td>0.054</td>
<td></td>
<td>0.009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td>0.194</td>
<td>0.193</td>
<td>0.126</td>
<td>0.147</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td>0.335*</td>
<td>0.121</td>
<td>0.286*</td>
<td>0.241*</td>
<td>0.068*</td>
<td>0.333</td>
<td>0.577*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTELL</td>
<td>0.353*</td>
<td>0.355*</td>
<td>0.252*</td>
<td>0.341*</td>
<td>0.055</td>
<td>0.225</td>
<td>0.055</td>
<td>0.162</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>0.120</td>
<td>0.035</td>
<td>0.025</td>
<td>0.002</td>
<td>0.002</td>
<td>0.158</td>
<td>0.348*</td>
<td>0.244*</td>
<td>0.200</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- + Denotes significance at 0.05 level for a two-tailed test.
- *TIPS = (POST-TEST 1 - POST-TEST 2) / (SCORE - POST-TEST 2 SCORE)* is discussed in Section 8.2.4.3.
- **In Section 8.2.4.3, the correlation coefficient between two variables is denoted by a positive symbol (+) for a two-tailed test.**
- **If a variable is not included as a linear correlation coefficient with any other variable, the negative of that for D1. The meanings of all dummy variables is explained in Section 8.2.4.4.**
- **Means 'not calculated'.
8.2.4.1 Analysis of Post-test Contd.

The dummy variables D1 to D5 were created by the appropriate control statements as follows.*

IF (METHOD EQ 1) D1 = 1 (lecture-group)
IF (METHOD EQ 2) D2 = 1 (microfiche-group)
IF (TEACHER EQ 1) D3 = 1 (first teacher of part-time subjects)
IF (TEACHER EQ 2) D4 = 1 (second teacher of part-time subjects)
IF (TEACHER EQ 3) D5 = 1 (teacher of full-time subjects)

For the first sequence (on the previous page) the output of the SPSS REGRESSION sub-programme can be tabulated as shown in Table 8-8 (a).

The percentage of variance accounted for by the independent variables is about 37% which is close to the $R^2$ value obtained from the ANOVA sub-programme (Table 8-6 (c)).

In this case we obtain much the same results whether we use the hierarchical values and calculate $R$ for each variable using the appropriate formula (equation 5-27) or calculate $F$ for each variable as if it had been entered last ($F_3$ and $F_4$ respectively).

Pre-test and intelligence are both very significant and between them account for $0.269 \times 100 = 85\%$ of the explained variance and method only $0.024 \times 100 = 7.5\%$ of the explained variance (its contribution to the overall variance in the dependent variable being only 2.4%). The marginal superiority lies with the microfiche-group in this instance.

* Footnote to Section 5.3.4 is also pertinent here of course, i.e. only 3 of the 5 dummy variables will appear in the regression output.
TABLE 8-8 (a)

REGRESSION ANALYSIS FOR "COMPLEX NUMBERS"

DEPENDENT VARIABLE = POST-TEST 1 5 C(36).

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRE-TEST</td>
<td>11.807 (0.001)</td>
<td>0.390</td>
<td>0.152</td>
<td>0.152</td>
<td>0.390</td>
<td>11.807 (0.001)</td>
<td>13.560 (55)</td>
<td>10.670 (0.002)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>10.397 (0.002)</td>
<td>0.518</td>
<td>0.269</td>
<td>0.117</td>
<td>0.355</td>
<td>11.942 (0.001)</td>
<td>10.465 (55)</td>
<td>12.569 (0.001)</td>
</tr>
<tr>
<td>3</td>
<td>AGF</td>
<td>0.641 (0.426)</td>
<td>0.525</td>
<td>0.276</td>
<td>0.007</td>
<td>0.035</td>
<td>8.131 (0.001)</td>
<td>0.626 (NS)</td>
<td>0.504 (0.480)</td>
</tr>
<tr>
<td>4</td>
<td>D3, D5 (TEACHER)</td>
<td>1.260 (0.266)</td>
<td>0.541</td>
<td>0.293</td>
<td>0.017</td>
<td>-0.133</td>
<td>5.146 (0.001)</td>
<td>1.521 (NS)</td>
<td>1.132 (0.292)</td>
</tr>
<tr>
<td>5</td>
<td>D2 (METHOD)</td>
<td>2.169 (0.146)</td>
<td>0.564</td>
<td>0.318*</td>
<td>0.024</td>
<td>0.048</td>
<td>4.730 (0.001)</td>
<td>2.169 (NS)</td>
<td>2.169 (0.146)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.250
TABLE 8-8 (b)

REGRESSION ANALYSIS FOR "COMPLEX NUMBERS"

DEPENDENT VARIABLE = POST-TEST SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEPENDENT VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1 (METHOD)</td>
<td>0.154</td>
<td>0.048</td>
<td>0.002</td>
<td>0.002</td>
<td>-0.048</td>
<td>0.154</td>
<td>0.048</td>
<td>0.146</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.696)</td>
<td></td>
<td></td>
<td></td>
<td>(0.696)</td>
<td>(NS)</td>
<td>(0.146)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PRE-TEST</td>
<td>0.414</td>
<td>0.414</td>
<td>0.171</td>
<td>0.169</td>
<td>0.390</td>
<td>6.717</td>
<td>15.072</td>
<td>10.670</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td>(0.002)</td>
<td>(SS)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>0.542</td>
<td>0.542</td>
<td>0.293</td>
<td>0.122</td>
<td>0.355</td>
<td>8.853</td>
<td>10.880</td>
<td>12.569</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AGE</td>
<td>0.550</td>
<td>0.550</td>
<td>0.302</td>
<td>0.009</td>
<td>-0.035</td>
<td>6.813</td>
<td>0.803</td>
<td>0.504</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.379)</td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.480)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D3; D5; TEACHER</td>
<td>0.563</td>
<td>0.563</td>
<td>0.317</td>
<td>0.015</td>
<td>-0.133</td>
<td>4.730</td>
<td>1.338</td>
<td>1.132</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.292)</td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.292)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.292)</td>
<td></td>
<td></td>
<td></td>
<td>(0.292)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*adjusted R² = 0.250*
8.2.4.1 Analysis of Post-Test 1 Contd.

Dummy variables D1 and D4 were not entered on the summary table by the computer as they add nothing further to the analysis. Even D5 is making virtually no contribution to the explained variance (the actual value of $\Delta R^2$ is 0.00024 on the computer print-out but values on Table 8-8 (a) are only given to three significant figures).

For the second sequence of variables the results obtained are shown in Table 8-8 (b).

Here D1 is the method variable processed. The Table shows that method effects do not become anything like significant even when they are processed first. (Recall $\eta^2 = 0.004$ from Table 8-6(c)).

.2 Analysis of Post-Test 2

For this topic we are able to also analyze the Post-test 2 using multiple regression analysis as the number of subjects (68) is the same as for Post-test 1, and a meaningful comparison of results is possible.

Once again we enter the independent variables in the usual sequence for the hierarchical procedure.

Post-test 1, Intelligence, age, D3 to D5 together ("teacher" variables) D1 and D2 together (method variables)

It was decided that there would be little purpose served by processing the method variables first, in view of the results obtained for Post-test 1. Table 8-8 (c) summarizes the results obtained for Post-test 2.

Again method is making a negligible contribution to the variance in the dependent variable, only 0.2%. However the Table 8-8 (c) shows some interesting results. Intelligence has faded out as a significant contributor to explained variance, its effects being taken up by Post-test 1 which now accounts for nearly 25% of the variance in the dependent variable (and 77% of the explained variance). On the other hand, teacher effects are now quite
### TABLE 8-8 (c)

**REGRESSION ANALYSIS FOR "COMPLEX NUMBERS"**

**DEPENDENT VARIABLE = POST-TEST 2 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEPENDENT VARIABLE</th>
<th>F1</th>
<th>R1</th>
<th>R2</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POST-TEST 1</td>
<td>26.498</td>
<td>0.535</td>
<td>0.286</td>
<td>0.286</td>
<td>0.535</td>
<td>26.498</td>
<td>27.736</td>
<td>15.827</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>0.412</td>
<td>0.539</td>
<td>0.291</td>
<td>0.004</td>
<td>0.753</td>
<td>13.337</td>
<td>0.390</td>
<td>1.914</td>
</tr>
<tr>
<td>3</td>
<td>AGE</td>
<td>0.310</td>
<td>0.543</td>
<td>0.294</td>
<td>0.003</td>
<td>0.025</td>
<td>8.900</td>
<td>0.291</td>
<td>1.782</td>
</tr>
<tr>
<td>4</td>
<td>D3 (TEACHER)</td>
<td>0.031</td>
<td>0.547</td>
<td>0.300</td>
<td>0.005</td>
<td>-0.126</td>
<td>7.266</td>
<td>0.485</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>D5 (METHOD)</td>
<td>6.865</td>
<td>0.608</td>
<td>0.360</td>
<td>0.070</td>
<td>0.286</td>
<td>6.789</td>
<td>6.474</td>
<td>0.013</td>
</tr>
<tr>
<td>5</td>
<td>D2 (METHOD)</td>
<td>0.191</td>
<td>0.609</td>
<td>0.371</td>
<td>0.002</td>
<td>-0.054</td>
<td>6.01</td>
<td>0.191</td>
<td>0.191</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.310
8.2.4.2 Analysis of Post-Test 2 Contd.

significant with F3 and F4 values of 6.789 and 6.474 respectively. These results are similar to those obtained with the ANOVA sub-programme (Tables 8-6 (d) to 8-6 (f)) although that analysis included some subjects who did not sit for the Pre-test and so were not included in the multiple regression analysis. Both sub-programmes give nearly the same value for R² (0.38 and 0.37 respectively) and both gave the amount of variance accounted for by method as nearly zero.

3 Analysis of Composite Post-Test Scores

The percentage of variance accounted for in Post-tests 1 and 2 were about 32% and 37%, respectively. While sufficient for the purposes of the analysis it was felt that more variance might be accounted for by having the computer create a new variable which is the mean of the Post-test 1 and 2 scores for each subject.

The appropriate control statement was thus:

\[ \text{COMPUTE } Z = \frac{X + Y}{2} \]

where \( X \) and \( Y \) are the Post-test 1 and 2 scores respectively.

When \( Z \) was used as a dependent variable with Pre-test as a covariate, the amount of variance accounted for increased to about 40% with direct method effects accounting for 1.5% of the variance in \( Z \) the "composite Post-test score" and "teacher" effects accounting for 3.0% of the variance when entered on Step 4 (as in Table 8-8 (a)).

The SPSS ANOVA sub-programme gave nearly identical results with \( R^2 = 0.400 \), \( \eta^2 = 0.063 \) for "teacher" and \( \eta^2 = 0.000 \) for method, the latter two values, of course, being unadjusted for covariates or the other factor.

As a dependent variable the "composite Post-test score" has certain advantages. On the one hand it is probably less vulnerable to extraneous sources of variance than either Post-test 1 and 2 alone and thus more reliable in the purely statistical sense. On the other hand, it measures a combination of longer and shorter term method effects which are difficult to disentangle. Probably
8.2.4.3 Analysis of Composite Post-Test Scores Contd.

A good procedure would be to see whether one obtains a significant or near-significant effect with the composite Post-test score and then carry out further analyses to determine whether the effect is due to differences in retention rates or in learning rates.

4 Analysis of Time Taken by Self-Paced Subjects on "Complex Numbers"

As in the case of the Preparatory Mathematics class and the topic "Complex Numbers" the times taken by the self-paced subjects were recorded. Table 8-8 (d) shows the correlation matrix equivalent to Table 8-3 (e). It is for microfiche self-paced subjects only, the booklet group being excluded in this case.

TABLE 8-8 (d)
CORRELATION MATRIX FOR "COMPLEX NUMBERS" SELF-PACED SUBJECTS

N = 32

<table>
<thead>
<tr>
<th></th>
<th>PRE-TEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>TT</th>
<th>POST-TEST 1</th>
<th>PRE-TEST</th>
<th>INTELL</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-TEST</td>
<td>0.117</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTELL</td>
<td>0.464*</td>
<td>-0.044</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>-0.013</td>
<td>-0.175</td>
<td>-0.323</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TT</td>
<td>-0.393*</td>
<td>-0.202</td>
<td>-0.362*</td>
<td>0.280</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* denotes significance at the 0.05 level for a two-tailed test.

Pre-test score is not significantly correlated with any other variable for the self-paced group* but intelligence is significantly correlated with Post-test 1 scores and also, inversely, with the time taken, as expected.

(Figure 8-1 shows that Pre-test scores were quite low for the self-paced group and so we would not expect it to be an important predictor of Post-test 1 scores).
8.2.4.4 Analysis of Time Taken by Self-Paced Subjects on "Complex Numbers"
Contd.

TT is significantly correlated with both Post-test 1 scores and intelligence and also correlated, though not significantly, with age. As with "Simultaneous Equations" younger and brighter subjects finished in a shorter time than the others.

To investigate whether time taken, TT, is a significant factor in its own right, in determining Post-test 1 scores, after adjusting for Pre-test, intelligence and age, as well as for the teacher variable, a multiple regression analysis was carried out in the usual fashion. We then processed TT first in order to determine its "total effect". The results are shown in Tables 8-8 (e) and 8-8 (f).

Because of the large amount of unexplained variance not much credence should be placed upon the precise values of the statistical and \( \Delta R^2 \) values in Tables 8-8 (e) and 8-8 (f). Also adjusted \( R^2 \) is quite low and the sample size too small for accurate analysis. Nevertheless we see that TT is not significant when processed last but when processed first its contribution to the variance in Post-test 1 becomes significant to the 0.05 level.* The subjects are working at individual rates which do significantly reflect their intelligences in this case, prior-knowledge not being sufficiently important to show up as significant in the analysis.

5 Comparison of Instructional Periods

Table 8-9 lists the instructional periods spent by the various groups for the topics investigated.

* In Table 8-8 (e) 6.8% may seem a reasonably large contribution until one realises that \( R^2 \) is only about 34% and \( N - k - 1 \) is only 25. Thus F3 is only about 2.6 which is not significant for degrees of freedom of 1 and 25.
**TABLE 8-8 (e)***

**REGRESSION ANALYSIS FOR SELF-PACED SUBJECTS**

**TOPIC: "COMPLEX NUMBERS"**

**DEPENDENT VARIABLE = POST-TEST 1 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEPENDENT VARIABLE</th>
<th>$F_1$ (DF)</th>
<th>$R$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>$r$</th>
<th>$F_2$ (DF)</th>
<th>$F_3$ (DF)</th>
<th>$F_4$ (DF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRE-TEST</td>
<td>0.415 (5)</td>
<td>0.117</td>
<td>0.014</td>
<td>0.014</td>
<td>0.117</td>
<td>0.415 (5)</td>
<td>0.527 (NS)</td>
<td>0.550 (0.465)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>8.366 (5)</td>
<td>0.484</td>
<td>0.235</td>
<td>0.221</td>
<td>0.464</td>
<td>4.442 (5)</td>
<td>8.321 (55)</td>
<td>3.227 (0.085)</td>
</tr>
<tr>
<td>3</td>
<td>AGE</td>
<td>1.181 (5)</td>
<td>0.515</td>
<td>0.265</td>
<td>0.013</td>
<td>-0.013</td>
<td>3.374 (55)</td>
<td>1.167 (NS)</td>
<td>1.114 (0.301)</td>
</tr>
<tr>
<td>4</td>
<td>TEACHER</td>
<td>0.085 (3)</td>
<td>0.517</td>
<td>0.267</td>
<td>0.002</td>
<td>0.107</td>
<td>1.903 (128)</td>
<td>0.075 (NS)</td>
<td>0.006 (0.981)</td>
</tr>
<tr>
<td>5</td>
<td>TT</td>
<td>2.578 (6)</td>
<td>0.580</td>
<td>0.336*</td>
<td>0.068</td>
<td>-0.393</td>
<td>2.112 (68)</td>
<td>2.578 (NS)</td>
<td>2.578 (0.121)</td>
</tr>
</tbody>
</table>

* $\Delta R^2$ for the adjusted $R^2$ is 0.178.
TABLE 8-8 (f)

REGRESSION ANALYSIS FOR SELF-PACED SUBJECTS

TOPIC: "COMPLEX NUMBERS"

DEPENDENT VARIABLE = POST-TEST 1 SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TT</td>
<td>5.493</td>
<td>0.393</td>
<td>0.155</td>
<td>-0.393</td>
<td>5.493</td>
<td>0.026</td>
<td>5.836</td>
<td>2.578</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.824)</td>
<td></td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(NS)</td>
<td>(S)</td>
<td>(NS)</td>
</tr>
<tr>
<td>2</td>
<td>PRE-TEST</td>
<td>0.050</td>
<td>0.395</td>
<td>0.156</td>
<td>0.001</td>
<td>0.117</td>
<td>2.685</td>
<td>0.085</td>
<td>0.550</td>
</tr>
<tr>
<td></td>
<td>(0.824)</td>
<td>(0.026)</td>
<td></td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(NS)</td>
<td>(NS)</td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>4.854</td>
<td>0.530</td>
<td>0.281</td>
<td>0.125</td>
<td>0.464</td>
<td>3.646</td>
<td>0.025</td>
<td>3.227</td>
</tr>
<tr>
<td></td>
<td>(0.036)</td>
<td>(0.091)</td>
<td></td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(NS)</td>
</tr>
<tr>
<td>4</td>
<td>AGE</td>
<td>1.751</td>
<td>0.570</td>
<td>0.325</td>
<td>0.044</td>
<td>-0.013</td>
<td>3.246</td>
<td>0.027</td>
<td>1.657</td>
</tr>
<tr>
<td></td>
<td>(0.197)</td>
<td>(0.197)</td>
<td></td>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
<td>(S)</td>
<td>(S)</td>
</tr>
<tr>
<td>5</td>
<td>D4 {</td>
<td>0.001</td>
<td>0.573</td>
<td>0.328</td>
<td>0.004</td>
<td>0.107</td>
<td>2.111</td>
<td>0.088</td>
<td>0.249</td>
</tr>
<tr>
<td></td>
<td>TEACHER</td>
<td>(0.981)</td>
<td>(0.981)</td>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
<td>(NS)</td>
</tr>
<tr>
<td>D4</td>
<td>D4</td>
<td>0.297</td>
<td>0.580</td>
<td>0.336*</td>
<td>0.008</td>
<td>-0.150</td>
<td>0.297</td>
<td>0.591</td>
<td>0.297</td>
</tr>
<tr>
<td></td>
<td>(0.591)</td>
<td>(0.591)</td>
<td></td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
<td>(S)</td>
</tr>
</tbody>
</table>

* adjusted $R^2 = 0.178$
8.2.5 Comparison of Instructional Periods Contd.

TABLE 8-9

COMPARISON OF INSTRUCTIONAL PERIODS (MINUTES)

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>LECTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vectors</td>
<td>48.9 94.6</td>
<td>56.9 110.7</td>
<td>38.0 0.0</td>
</tr>
<tr>
<td>Mean</td>
<td>S.D.</td>
<td>Variance</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.7</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>10.5</td>
<td>110.7</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>38.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>2. Complex Numbers (full-time)</td>
<td>39.9 309.1</td>
<td>26.8 29.6</td>
<td>38.0 0.0</td>
</tr>
<tr>
<td>Mean</td>
<td>S.D.</td>
<td>Variance</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>17.6</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>5.4</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>309.1</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>3. Complex Numbers (full and part-time combined)</td>
<td>50.0 174.9</td>
<td>-</td>
<td>43.0</td>
</tr>
<tr>
<td>Mean</td>
<td>S.D.</td>
<td>Variance</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>13.2</td>
<td>13.2</td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>-</td>
<td>(MEAN FOR THREE LECTURES)</td>
<td></td>
</tr>
</tbody>
</table>

As in the case of the "Preparatory Mathematics" classes there is a considerable standard deviation for the times taken by students on self-paced learning. For topics 1 and 3 the average "natural time" taken by the subjects is about 15% greater than the lecture time on average and probably would have been greater had the slower subjects not found themselves racing against the clock. While the brighter students would have found little difficulty in following the lectures the weaker or slower students would have had considerable difficulty and would have been forced to work much faster than at their "natural rate". As we noted in Section 8.1.3, there are factors involved here other than those which can be gauged purely from objective achievement tests.

3 Distribution of Times Taken by Self-Paced Subjects

In the above discussions it has been tacitly assumed that the times taken by self-paced subjects have been normally distributed with the subject of
8.3 Distribution of Times Taken by Self-Paced Subjects Contd

average ability finishing at the average time taken.

Figures 8.4 and 8.5 graphically illustrate the time distributions taken for self-paced subjects on the topics "Simultaneous Equations" and "Complex Numbers" and compares them with a theoretical normal distribution calculated from the data on times taken.

In both cases an $\chi^2$ test indicates that the departure from normality is not significant at the 0.05 level.

For both topics we see that only 40% of the subjects had finished by the conclusion of the time taken for the lecture period. As the subjects appeared to work steadily on the self-paced programmes throughout the instructional period the "natural speed" of most subjects is again seen to be slower than catered for by the lecture situation.

The standard deviation of the time taken by the Preparatory Mathematics subjects is seen to be considerably greater than that for the Stage 1 Mathematics subjects. This is possibly due to the inclusion of the booklet-group, together with the microfiche-group in Figure 8.4 which introduces an additional source of variance. For both topics about 50% of subjects had finished by the mean time taken as expected, for a near normal distribution.

4 Item Analysis for Complex Numbers Data

So far our analysis has been concerned with total scores on Pre-tests and Post-tests 1 and 2. However, a subject's total score gives no indication of how this score is distributed amongst the various test items, each item measuring a particular manipulatory or conceptual skill, or set of skills.

Figure 8-6 shows diagrammatically an item analysis carried out on the Pre-test and Post-test 1 for the topic "Complex Numbers". Because individual items measure more specific attributes than total test scores, the variability in item scores will be considerably greater than that in total test scores which are, to some extent, "integrated".

While the microfiche-group performs somewhat worse than the lecture-group on all items in the Pre-test, a t test for independent samples shows that
This is a graph showing the percentage of students finishing 'Simultaneous Equations' with a lecture and without a lecture. The graph indicates that the students who attended the lecture had a higher percentage of finishing the topic compared to those who did not.
Fig. 8-5 "Times taken by self-paced students on the topic "Complex Numbers"
8.4 Item Analysis for Complex Numbers Data Contd.

the differences are only significant at the 0.05 level for items 7 and 8. Both groups improve significantly on most items and the overall mean item scores for both groups on Post-test 1 are almost identical.

Although Figure 8-6 suggests that the microfiche-group learns more during the instructional period when Pre-test is taken into account, a full analysis taking into account all relevant variables and the complete data for each individual subject is necessary to find out whether this is significant. The analysis carried out in Section 8.2.2 showed that, in fact, method was not having an overall statistically significant effect in this case.

It is interesting to note that the item score profiles follow nearly the same pattern for both groups. Apart from random statistical fluctuations the lecture-group performs better than the microfiche-group on items 1 and 10 of Post-test 1 even after Pre-test scores are taken into account. Possibly the lecturers spent more time on the pre-requisite skills for these items although they are covered in the programme. For item 3 the lecture-group made very little improvement between Pre-test and Post-test 1 although many subjects had scored well on this item in the Pre-test. This was because the answer required was \(0 + 10\) (null point on the Argand plane) which was explained in the programme but probably the lecturers had not distinguished this from the non-complex form, \(0\) (null point on the Cartesian plane).

Both groups of subjects tended to find the same items either easy or difficult although the figure does not tell us whether the subjects who found one "high score" item easy also found another "high score" item easy. Both groups tended to find items 2, 5, 6 and 7 relatively easy, had moderate success with items 3, 4 and 8, and found items 9 or 10 difficult or unable to be completed in the allocated time. However the differences between the items is not sufficiently clear-cut to warrant further analysis at this level.

8.5 Summary

A series of experimental runs were carried out using Preparatory Mathematics and Stage 1 Mathematics students at Kilkenny College of Further
8.5 Summary Contd.

Education. Several topics were investigated and populations employed ranged from about 30 to 90. Various allocation procedures were employed to allocate students to two or more groups. Several teaching situations were investigated including didactic teaching and self-paced learning from microfiche and booklets. Small group versus individualized self-instruction was also investigated in some instances.

(a) No direct method effects were significant at the 0.05 level in objective test scores. Although for one topic, "Simultaneous Equations", method effects were approaching significance with the lecture situation having the edge.

(b) Method was found to account for only about 2.5% of the total variance in Post-test 1 whether the latter was processed first or last in the analysis. At the most it only accounted for 10% of the explained variance thus occurring when it is processed first in the analysis for the topic "Simultaneous Equations" so that the "method effect" is probably due to differences in the initial groups in this instance.

(c) The use of small groups in self-paced situations did not significantly affect the test score results.

(d) The distribution of times taken by self-paced subjects was approximately normal, a detailed analysis showing that the self-paced subjects worked at a rate determined by their prior-knowledge of the topic and/or intelligence. Most subjects spent considerably longer on the programmes than the duration of the lecture period.

(e) Analysis of covariance was used in all cases and multiple regression analysis which was used for "Simultaneous Equations" and "Complex Numbers", where the sample numbers were deemed adequate for this method, and for the purposes of this investigation, produced similar results.

(f) An item analysis for the topic "Complex Numbers" showed that subjects found the same items easy or difficult for this topic, irrespective of method.
9. DISCUSSION OF EMPIRICAL RESULTS II: THE STAGE ONE SCIENCE PROJECT

This Section discusses the empirical results obtained using the part-time Stage 1 Science class at Kilkenny College of Further Education.

Most, although not all, of the subjects were also attending Mathematics 1 classes and many had thus had prior exposure to microfiche. As only about 50 subjects participated in the experiments, which were held in third term, it was decided to use only two teaching methods or situations.

(a) the conventional lecture
(b) self-paced instruction from microfiche

Two topics were employed these being "Inductive Reactance" and "Capacitive Reactance" as described in Section 7.3. In that Section there is also a full discussion of the experimental procedure which will not be reiterated here.

The programme used for these topics were not branched but linear owing to the preference of the science lecturer. The science lecturer was actively involved in the design of the programmes and also designed the Pre-test and Post-tests 1 and 2 in collaboration with members of the research team.

A set of objectives were first set out and agreed upon, to assist the lecturer in the preparation of the programme and in setting the tests. These are given in Appendix 6.*

Unlike in the mathematical programmes a "cuing" technique was employed; information sequences were followed by relevant questions with key words missing for the subject to fill in either mentally or on a sheet of paper.

The correct answer was then given at the top of the next frame. Questions on the same information sequence had the cue words progressively reduced until, at the end of the relevant section, appeared a complete question without cues.

* Similar objectives were set out for other topics but for brevity are not included in this Report.
In this way it was hoped that much of the factual content of the programme would be conveyed to the subjects together with the mathematical manipulations to test their conceptual knowledge.*

We noted previously that the Pre-test marks for many subjects on topics such as "Simultaneous Equations" or "Complex Numbers" were low due to little prior-knowledge of the topic and possibly lack of skill in pre-requisite topics, such as "Algebraic Equations" or "Vectors" respectively for the topics cited. In order to avoid this the lecturer taught all the necessary pre-requisites such as "capacitance" and "alternating currents" and tried to ensure that the subjects had a good grasp of these before the experiment, so that Pre-test measured lack of knowledge of the topic proper and not lack of knowledge of basic pre-requisites as well.

1 Population Data

Table 9-1 (a) shows the population test data for the two topics, all marks being out of 30.

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>t12</th>
<th>t23</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inductive Reactance</td>
<td>Mean</td>
<td>5.95</td>
<td>17.25</td>
<td>18.68</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>6.39</td>
<td>7.90</td>
<td>8.31</td>
<td>(0.001)</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>40.78</td>
<td>62.47</td>
<td>69.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 49)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Capacitive Reactance</td>
<td>Mean</td>
<td>11.43</td>
<td>19.90</td>
<td>19.38</td>
<td>8.59</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>9.54</td>
<td>7.22</td>
<td>7.24</td>
<td>(0.001)</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>91.10</td>
<td>52.19</td>
<td>52.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 44)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes to Tables 9-1(a) & 9-1(b) are as for those for Table 8-1, Section 8.

* See discussions of various theories of learning in Section 3. The linear programme could readily be converted to a branching one, and the two topics could be included on one single programme using a finer grid format, depending upon the specific requirements of the lecturer and students. This linear system means, of course, that all subjects work through all frames before they conclude the programme, whereas with a branching programme subjects with a good deal of prior-knowledge of the topic, or who are exceptionally bright, can by-pass branches which add nothing to their understanding of the topic.

Only 38 subjects sat for the Pre-test for "Inductive Reactance", while all 49 sat for both Post-tests 1 and 2. Thus t12 and t23 refer to slightly different populations.

For "Capacitive Reactance" 43 out of the 44 subjects sat for the Pre-test and so the t12 and t23 refer to nearly the same populations.

Table 9-1 (a) shows that there was a very significant increase between Pre-test score and Post-test 1 score but no significant increase between the Post-tests 1 and 2. Post-test 2 was thus probably a reasonable "retention test" although, as described in Section 7.3, Post-test 2 for "Inductive Reactance" was given subsequent to the instructional period on "Capacitive Reactance". (This could explain why t23 was as high as 1.61 although, of course, this was still not significant).

Table 9-1 (b) shows the group data for the topic "Inductive Reactance". The data for "Capacitive Reactance" will be similar as the groups were basically the same, but interchanged.

We see that the groups are well matched on all relevant variables and one can re-investigate, for example, interaction effects between method and the other independent variables without worrying too much about differences in the initial samples.

Figure 9-1 shows the Pre-test and Post-test 1 scores for the lecture and microfiche-groups for both topics. For X1 (or "Inductance" as it is labelled on the figure) the mean Pre-test scores only refer to the subjects who sat for that test and so not too much credance should be attached to their exact values. However it is clear that

(a) The microfiche-group increased their performance considerably more than the lecture-group for X1.

(b) Both groups found Xc considerably easier than X1 and method effects fade out.*

These phenomena will be examined in more detail as the discussion proceeds.

* X1 and Xc are used to denote inductive and capacitive reactance respectively.
FIG. 9-1
PRE-TEST AND POST-TEST 1
SCORES

- Capacitance
- Inductance
- Lecture
- Film

Pretest  | Posttest 1
Score   | Score
STAGE ONE SCIENCE

TABLE 9-1 (b) GROUP DATA (for inductive reactance)

<table>
<thead>
<tr>
<th></th>
<th>LECTURE</th>
<th>FICHE</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>115.2</td>
<td>116.5</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>10.6</td>
<td>7.9</td>
<td>(NS)</td>
</tr>
<tr>
<td></td>
<td>112.8</td>
<td>62.4</td>
<td></td>
</tr>
<tr>
<td>(N = 27)</td>
<td></td>
<td>(N = 22)</td>
<td></td>
</tr>
<tr>
<td>FM</td>
<td>58.8</td>
<td>60.0</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>11.6</td>
<td>18.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>135.1</td>
<td>336.1</td>
<td>(NS)</td>
</tr>
<tr>
<td>(N = 27)</td>
<td></td>
<td>(N = 21)</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>23.8</td>
<td>25.0</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>6.9</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>47.3</td>
<td>99.1</td>
<td>(NS)</td>
</tr>
<tr>
<td>(N = 27)</td>
<td></td>
<td>(N = 22)</td>
<td></td>
</tr>
<tr>
<td>PRETEST</td>
<td>6.2</td>
<td>5.7</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>6.5</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>41.7</td>
<td>42.0</td>
<td>(NS)</td>
</tr>
<tr>
<td>(N = 21)</td>
<td></td>
<td>(N = 17)</td>
<td></td>
</tr>
</tbody>
</table>

\( t \) is \( t \) value for independent samples.
FM denotes "final mark".
N.S. means "not significant" at 0.05 level of significance for two-tailed test.

9.2 Analysis of Covariance

Discussions of this method were given in Sections 5.3.1 and 8.1.2 so we can enter immediately into a discussion of Post-test 1 results.

.1 Analysis of Post-test 1

Tables 9-2 (a) to 9-2 (c) summarize the Stage 1 Post-test 1 score results obtained using the SPSS ANOVA sub-programme.*

Although the effective sample sizes are small the Tables are quite informative and an attempt has been made to control as many relevant variables as possible. "Final mark" is the final mark obtained by each subject at the end of the year assessment (an examination plus term assignments and tests). As the final exam was held only shortly after the conclusion of the experiment, and the results were available to the researchers, it was felt a worthwhile exercise to carry out SPSS runs with and without final mark as a covariate.

* For convenience of discussion, in this case 'Topic' refers both to content and to the analysis used.
<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>FINA MARK (FM)</th>
<th>METHOD</th>
<th>PREVIOUS EXPERIENCE (PE)</th>
<th>METHOD X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A  INDUCTIVE REACTANCE</td>
<td>0.001</td>
<td>0.476</td>
<td>0.566</td>
<td>-</td>
<td>0.011</td>
<td>0.011</td>
<td>0.187</td>
</tr>
<tr>
<td>1B  INDUCTIVE REACTANCE</td>
<td>0.001</td>
<td>0.549</td>
<td>0.583</td>
<td>0.423</td>
<td>0.026</td>
<td>0.013</td>
<td>0.240</td>
</tr>
<tr>
<td>(WITH FM INCLUDED IN ANALYSIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A  CAPACITIVE REACTANCE</td>
<td>0.001</td>
<td>0.457</td>
<td>0.734</td>
<td>-</td>
<td>0.784</td>
<td>0.068</td>
<td>0.886</td>
</tr>
<tr>
<td>2B  CAPACITIVE REACTANCE</td>
<td>0.001</td>
<td>0.651</td>
<td>0.689</td>
<td>0.016</td>
<td>0.837</td>
<td>0.053</td>
<td>0.492</td>
</tr>
<tr>
<td>(WITH FM INCLUDED IN ANALYSIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 9.2 (b)

**ANALYSIS OF POST-TEST 1 (WITH PRETEST AS A COVARIATE)**

**VALUES OF F**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>FINAL MARK (FM)</th>
<th>METHOD</th>
<th>PREVIOUS EXPERIENCE (PE)</th>
<th>METHOD X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1A INDUCTIVE REACTANCE</strong></td>
<td>51.439</td>
<td>0.107</td>
<td>0.337</td>
<td>-</td>
<td>7.355</td>
<td>7.317</td>
<td>1.822</td>
</tr>
<tr>
<td><strong>1B INDUCTIVE REACTANCE</strong></td>
<td>38.837</td>
<td>0.167</td>
<td>0.309</td>
<td>0.659</td>
<td>5.491</td>
<td>6.986</td>
<td>1.422</td>
</tr>
<tr>
<td>(WITH FM INCLUDED IN ANALYSIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2A CAPACITIVE REACTANCE</strong></td>
<td>37.431</td>
<td>0.540</td>
<td>0.117</td>
<td>-</td>
<td>0.076</td>
<td>3.528</td>
<td>0.023</td>
</tr>
<tr>
<td><strong>2B CAPACITIVE REACTANCE</strong></td>
<td>15.058</td>
<td>0.160</td>
<td>0.163</td>
<td>6.472</td>
<td>0.043</td>
<td>4.002</td>
<td>0.494</td>
</tr>
<tr>
<td>(WITH FM INCLUDED IN ANALYSIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOPIC</td>
<td>FACTOR</td>
<td>ETA</td>
<td>BETA</td>
<td>MULTIPLE R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>-----</td>
<td>------</td>
<td>------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A</td>
<td>INDUCTIVE REACTANCE</td>
<td>METHOD**</td>
<td>0.28</td>
<td>0.28</td>
<td>0.824</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PE***</td>
<td>0.71</td>
<td>0.41</td>
<td>(0.679)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 37)</td>
<td></td>
<td>(0.078)</td>
<td>(0.078)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>INDUCTIVE REACTANCE (WITH FM INCLUDED IN ANALYSIS)</td>
<td>METHOD</td>
<td>0.28</td>
<td>0.25</td>
<td>0.833</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PE</td>
<td>0.73</td>
<td>0.41</td>
<td>(0.694)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 37)</td>
<td></td>
<td>(0.078)</td>
<td>(0.063)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>CAPACITIVE REACTANCE</td>
<td>METHOD</td>
<td>0.00</td>
<td>0.03</td>
<td>0.737</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PE</td>
<td>0.69</td>
<td>0.40</td>
<td>(0.543)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 43)</td>
<td></td>
<td>(0.000)</td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>CAPACITIVE REACTANCE (WITH FM INCLUDED IN ANALYSIS)</td>
<td>METHOD</td>
<td>0.04</td>
<td>0.02</td>
<td>0.775</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PE</td>
<td>0.68</td>
<td>0.40</td>
<td>(0.600)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 33)</td>
<td></td>
<td>(0.002)</td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* squares of values are shown in brackets  ** two methods for each topic  *** two categories for each topic.
9.2.1 Analysis of Post-test Contd.

It may be argued that it is illogical to use final mark as a covariate as the final examination was held after Post-tests 1 and 2. But it is possible that the final examination result may involve additional relevant variables and thus account for variance in the dependent variable over and above that accounted for by Pre-test score, intelligence, age or previous experience.

Previous experience was another independent variable introduced as an attempt to account for additional variance in the dependent variable. This was thought important as some of the subjects had received prior-experience in science either at school or possibly at other post-secondary institutions whereas others had no experience at all in science and, despite the efforts of the teacher, possibly still found difficulty with such basic concepts as "alternating current", "phasor" or even "resistance".

The independent variables thus considered in the analysis were:

- Pre-test
- Intelligence
- Age
- Final Mark (FM)
- Method
- Previous experience (PE)

With the numbers involved no attempt was made to distinguish between degrees of previous experience and only two categories were created, either "previous experience" or "no previous experience".

We will now discuss the effect of each independent variable in turn.

(a) Method Effects

Method is a significant variable for "Inductive Reactance" (X₁) with final mark, both included and excluded from the analysis but is not significant for "Capacitive Reactance" (Xᵢ). The value of \( \eta^2 \) for X₁ is 0.078. Thus about 6 - 8% of the variance is being accounted for by method, sufficient to well exceed the 0.05 significance level (Table 9-2 (a)) even after adjustments for other factors and covariates. This MCA Table
9.2.1 (a) **Method Effects Contd.**

on the SPSS output gives the unadjusted mean values, (not shown here) for the Post-tests as 15.97 - 1.95 = 14.02 for the lecture-group where 15.97 is the grand mean for the 38 subjects involved. The self-paced situation thus produces a significantly better result than the lecture situation.

We saw in our discussion of the experimental design (Section 5) that it was this positive result which prompted the researchers to try the second topic "Capacitive Reactance". If the above effect was due to the group rather than the method the, upon interchanging groups, the lecture situation should show up as significantly better than the self-paced situation. This did not, in fact, happen and both groups performed equally on the Post-test 1 for Xc with beta² dropping to near zero.

The reason for the significant method effect, the only one found in this entire research project, was apparently that for the new topic X1, the subjects learnt more from the self-paced situation than from the lecture situation. However, once the conceptual base and verbal definitions were established the subjects found Xc as easy to grasp by one method as by the other. Also for some reason which is not obvious, even to the lecturer, an experienced science teacher, students tend to find capacitive circuits easier to understand than inductive circuits. It would be instructive to repeat this experience at some time in the future with Xc given before X1 to see where method effects show up in this reversed design. Further investigation is certainly warranted.

(b) **Effects of Previous Experience**

Previous experience was a significant factor for X1, both with and without FM as a covariate, and was on the verge of significance for Xc.

For Topics 1A the MCA Table provided by the computer gives the unadjusted mean values for Post-test 1 as 15.97 - 5.81 = 10.16 for subjects with no previous experience and 15.96 + 5.23 = 21.19 for subjects with previous experience. This difference
9.2.1 (b) Effects of Previous Experience Contd.

of over 10 point scores, indicates that previous experience is a key factor and it remains so after the effects of all the covariates are taken into account. $\eta^2$ is a large 0.504 indicating that it accounts for about 50% of the variance in the Post-test 1 scores or about $0.504 \times 100 = 74\%$ of the explained variance when entered first into the analysis.

For $x_c$ previous experience is not quite so significant although for Topic 28 $\eta^2$ is still 0.462 and it still accounts for $0.462 \times 100 = 77\%$ of the explained variance when entered first. 0.600

The total amount of the explained variance is now less than for $x_l$ and when other independent variables are allowed for, the effect of previous experience drops below the significance level.

(c) Covariate Effects

The Pre-test again was the major source of variance explained by covariate effects. Intelligence was not significant for any topic after Pre-test is allowed for, although of course, it would probably become so were Pre-test to be dropped from the analysis. Age is not significant after adjusting for other covariates.*

Of interest is the significance of FH for Topic 28, with a standardized partial regression coefficient of 0.163 (cf with 0.379 for the Pre-test). For $x_c$ additional variables were thus operating to influence the performance on Post-test 1, these variables also leading to a greater final mark. Without further investigation it is difficult to say precisely what these are but the more conscientious subjects were possibly working harder at that time of the year due to the proximity of the final examinations.

* On the footnote to Section 8.1.2 (d) it was noted that "in some circumstances age could be significant after factors are adjusted for as well as other covariates". This could indeed be the case here where factors are accounting for a considerable amount of variance.
9.2.1 (d) Interaction Effects

We saw that for Topics 1A and 1B, both method and previous experience (PE) are significant, while PE was significant or nearly significant for all four topics. It was therefore important to investigate the possibility of interaction effects, i.e. whether subjects with previous experience performed better at self-paced learning than subjects with no previous experience. In fact no interaction effects were significant (see Table 9-2 (a)) although they could possibly have become so with larger samples, especially for Topics 1A and 1B.

.2 Analysis of Post-test 2

Tables 9-2 (d) to 9-2 (f) summarize the data for Post-test 2.

(a) Method Effects

Method effects are insignificant for all topics although they were significant in determining Post-test 1 scores for X1. For the latter all method effects have now apparently been taken up by Post-test 1 as a covariate. Thus there were no differences in retention rates between the two teaching methods. In all cases $\eta^2$ is only about 0.01 or less, accounting for only about 1% or less of the variance in Post-test 1.

(b) Effects of Previous Experience

As in the analysis of Post-test 1, previous experience is again significant for X1, the subjects with previous experience performing significantly better than those without such experience for Topics 1A and 1B. Table 9-2 (f) shows that PE accounts for about 40-45% of the variance in Post-test 2 if entered first into the analysis.

By the time the subjects sat for Post-test 2 on Xc one would expect PE to cease to be a meaningful variable as even subjects with no initial experience had received two lessons and sat for five tests on either X1 or Xc. In fact this was found to be the case with PE only accounting for about 1-2% of the variance. It is difficult to see why PE should be significant for Post-test 2 on X1 which was only given a week before. One possible
### Table 5-2 (a)

#### Analysis of Post-test 2 (With Post-test 1 as a Covariate)

**Significance of F Values**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Post-test 1</th>
<th>Intell</th>
<th>Age</th>
<th>FM</th>
<th>Method</th>
<th>PE</th>
<th>Method X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Inductive Reactance</td>
<td>0.001</td>
<td>0.979</td>
<td>0.911</td>
<td>-</td>
<td>0.678</td>
<td>0.015</td>
<td>0.664</td>
</tr>
<tr>
<td>18 Inductive Reactance (With FM included in analysis)</td>
<td>0.001</td>
<td>0.600</td>
<td>0.352</td>
<td>0.001</td>
<td>0.994</td>
<td>0.011</td>
<td>0.526</td>
</tr>
<tr>
<td>24 Capacitive Reactance</td>
<td>0.001</td>
<td>0.450</td>
<td>0.400</td>
<td>-</td>
<td>0.282</td>
<td>0.322</td>
<td>0.921</td>
</tr>
<tr>
<td>25 Capacitive Reactance (With FM included in analysis)</td>
<td>0.001</td>
<td>0.348</td>
<td>0.197</td>
<td>0.005</td>
<td>0.291</td>
<td>0.265</td>
<td>0.296</td>
</tr>
</tbody>
</table>
### Table 2-2 (e)

**Analysis of Post-test 2 (with Post-test 1 as a Covariate)**

**F Values**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Post-test 1</th>
<th>Intell</th>
<th>Age</th>
<th>FM</th>
<th>Method</th>
<th>PE</th>
<th>Method X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A Inductive Reactance</td>
<td>47.548</td>
<td>0.001</td>
<td>0.613</td>
<td>-</td>
<td>0.175</td>
<td>6.404</td>
<td>0.203</td>
</tr>
<tr>
<td>1B Inductive Reactance (with FM included in analysis)</td>
<td>24.514</td>
<td>0.065</td>
<td>0.887</td>
<td>22.860</td>
<td>0.000</td>
<td>7.087</td>
<td>0.409</td>
</tr>
<tr>
<td>2A Capacitive Reactance</td>
<td>95.451</td>
<td>0.583</td>
<td>0.726</td>
<td>-</td>
<td>1.192</td>
<td>1.009</td>
<td>0.010</td>
</tr>
<tr>
<td>2B Capacitive Reactance (with FM included in analysis)</td>
<td>43.888</td>
<td>0.905</td>
<td>1.730</td>
<td>8.921</td>
<td>1.149</td>
<td>1.285</td>
<td>1.127</td>
</tr>
</tbody>
</table>
### TABLE 9-2 (f)

**ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)**

**VALUES OF ETA, BETA, AND MULTIPLE R**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A INDUCTION REACTANCE</td>
<td>METHOD</td>
<td>0.09 (0.008)</td>
<td>0.04 (0.002)</td>
<td>0.759 (0.575)</td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>0.67 (0.449)</td>
<td>0.38 (0.144)</td>
<td></td>
</tr>
<tr>
<td>1B INDUCTION REACTANCE (WITH FM INCLUDED IN ANALYSIS)</td>
<td>METHOD</td>
<td>0.11 (0.012)</td>
<td>0.00 (0.000)</td>
<td>0.847 (0.717)</td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>0.67 (0.449)</td>
<td>0.38 (0.116)</td>
<td></td>
</tr>
<tr>
<td>2A CAPACITANCE REACTANCE</td>
<td>METHOD</td>
<td>0.09 (0.001)</td>
<td>0.10 (0.010)</td>
<td>0.854 (0.729)</td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>0.63 (0.357)</td>
<td>0.12 (0.014)</td>
<td></td>
</tr>
<tr>
<td>2B CAPACITANCE REACTANCE (WITH FM INCLUDED IN ANALYSIS)</td>
<td>METHOD</td>
<td>0.12 (0.014)</td>
<td>0.09 (0.001)</td>
<td>0.882 (0.778)</td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>0.62 (0.384)</td>
<td>0.12 (0.014)</td>
<td></td>
</tr>
</tbody>
</table>

* Squares of quantities are shown in brackets. ** Two methods ** Three categories
9.2.2 (b) Effects of Previous Experience Contd.
explanation is that all the subjects, irrespective of past
experience, found capacitive reactance considerably easier
than inductive reactance (see Section 9.2.1 (a)).

(c) Covariate Effects
As expected, Post-test 1 score was the most important source
of explained variance in the Post-test 2 scores taking up the
effects of intelligence. Age was again having no significant
effect, after adjusting for other covariates.

Final mark was now very significant for both X1 and Xc.
Indeed it increased the value of $R^2$ for X1 from about 0.575
to 0.717 and from 0.729 to 0.778 for Xc. Once again explana-
tion probably lies with the proximity of these tests to the
final examination (see Section 9.2.1 (c)).

Thus we have been able to detect a number of interesting and
significant results using the analysis of covariance procedure.
We will now see what further information can be obtained using
multiple regression analysis.

3 Multiple Regression Analysis

We noted in Section 8.2.4 that the SPSS regression sub-programme still
does not sort out 'missing data' properly. The handbook (Nie et al
p. 353) states that when the computer is not otherwise directed, all
cases with missing values are automatically eliminated from all calcu-
lations. The experience of the researchers, however, is that the sub-
programme actually does include such data but substitutes value of zero
for the missing data!

Thus care is needed in interpreting the SPSS print-out from the regres-
sion sub-programme if there is a considerable amount of missing data.
The means and standard deviations will be calculated with $N$ = number of
data cards rather than $N$ = number of cases without missing data for that
variable.

The following outputs were obtained from the same card deck as used for
the ANOVA sub-programme (Section 9.2). However all cases were now
9.3 Multiple Regression Analysis Contd.

processed with values of zero being substituted for missing data. The only instance when this was important was for the analysis of Post-test 1 for XI where 11 subjects did not sit for the Pre-test. Nevertheless the regression analysis is still a worthwhile exercise, as part of the increased variance thus introduced should be compensated for by intelligence, Fl and PE. Also the missing data is nearly evenly distributed between the lecture and self-paced groups.

However, the missing Pre-test values are all for subjects with no previous experience. Thus when all of these are given a Pre-test value of zero, the effects of PE should be greatly enhanced and account directly and indirectly for even more than the 50% of the variance bought out in the ANOVA analysis (Table 9-2 (c)).

The dummy variables D1 to D4 were created in the usual way by the appropriate control statements thus:

IF (METHOD EQ 1) D1 = 1 ("lecture")
IF (METHOD EQ 2) D2 = 1 ("microfiche")
IF (PE EQ 0) D3 = 1 ("no previous experience")
IF (PE EQ 1) D4 = 1 ("some previous experience")

Alternatively only two IF statements and two dummies would suffice, see footnote to Section 8.1.3.1.

As with "Complex Numbers" (Section 8.2.4) it is informative to alter the order of entry of the various independent variables.

Bearing in mind the results of the ANOVA analysis (Sub-Section 9.3) it was decided to enter the variables in two sequences as follows:

1. Pre-test (or Post-test 1)
2. D3, D4 (previous experience variables entered together)
3. Intelligence
4. FM
5. Age
6. D1, D2 (method variables entered together)

1. D1, D2 (method variables)
2. Pre-test (or Post-test 1)
3. D3, D4 (previous experience variables entered together)
4. Intelligence
5. FM
6. Age
9.3 **Multiple Regression Analysis** Contd.

The simple correlation matrices for the two topics are shown in Figures 9-2 (g) and 9-2 (h).

The multiple regression analysis will sort out the variables in Tables 9-2 (g) and 9-2 (h) so that the one taken as the dependent variable can be predicted from others in a predetermined order decided by the researcher. The Tables serve however to show the total relationship between any two variables. The dummies D2 and D4 are not included as the simple correlation coefficients between these and other variables will be the negative of that of D1 and D3 respectively, e.g. the simple correlation between D2 and intelligence will be $-0.213$ and between D4 and FM will be $0.443$ etc.

The Tables are included mainly for interest and a detailed discussion at this stage would distract from the main thrust of the subsequent analysis. However, one sees that intelligence and age appear to be only weakly associated with test performance, while previous experience and final mark are strongly associated with test performance. Method is only very weakly associated with test performance except for the Post-test 1 for X1 where $r$ reaches about $0.25$ with D1 as the method variable. Age is very weakly associated with test performance for Xc but for X1 it is approaching $-0.20$ for Post-test 1. We will see in Table 9-3 (a) that age and method do in fact make significant contributions to the variance in Post-test 1 for X1 after adjustments are made for other independent variables.

With 49 subjects for the X1 topic and 44 for the Xc topic the numbers in each teaching group were too small for a proper and reliable regression analysis. However, unreliable, in the sense of not being precisely reproducible, though the results may be, they should still throw considerable light on the experimental situation and give a pointer to the direction further research should or could take.

### 1 Analysis of Post-test 1

Tables 9-3 (a) and 9-3 (b) show the results of the multiple regression analysis for the two sequences of independent variables with X1.

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### FIGURE 9-2 (g)

**SIMPLE CORRELATION COEFFICIENTS FOR X1**

\( (N = 49) \)

<table>
<thead>
<tr>
<th></th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>INTELL</th>
<th>AGE</th>
<th>FM</th>
<th>D1</th>
<th>D3</th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>INTELL</th>
<th>AGE</th>
<th>FM</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-TEST 1</td>
<td>0.436*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST-TEST 2</td>
<td>0.452*</td>
<td>0.710*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>INTELL</td>
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<tr>
<td>AGE</td>
<td>0.147</td>
<td>-0.190</td>
<td>-0.244</td>
<td>-0.281*</td>
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</tr>
<tr>
<td>FM</td>
<td>0.289*</td>
<td>0.397*</td>
<td>0.617*</td>
<td>0.144</td>
<td>0.127</td>
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</tr>
<tr>
<td>D1</td>
<td>0.033</td>
<td>-0.247</td>
<td>-0.095</td>
<td>-0.207</td>
<td>-0.071</td>
<td>0.043</td>
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</tr>
<tr>
<td>D3</td>
<td>-0.435*</td>
<td>-0.689*</td>
<td>-0.671*</td>
<td>-0.042</td>
<td>-0.123</td>
<td>0.446*</td>
<td>0.092</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

* denotes significance at 0.05 level for a two-tailed test.
**FIGURE 9-2 (h)**

**SIMPLE CORRELATION COEFFICIENTS FOR Xc**

*(N = 44)*

<table>
<thead>
<tr>
<th></th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>INTELL</th>
<th>AGE</th>
<th>FH</th>
<th>01</th>
<th>D3</th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>INTELL</th>
<th>AGE</th>
<th>FM</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-TEST 1</td>
<td>0.704*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST-TEST 2</td>
<td>0.707*</td>
<td>0.838*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
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<td>INTELL</td>
<td>0.128</td>
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</tr>
<tr>
<td>AGE</td>
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<td>-0.079</td>
<td>-0.229</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM</td>
<td>0.561*</td>
<td>0.621*</td>
<td>0.648*</td>
<td>0.185</td>
<td>0.133</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>D1</td>
<td>-0.040</td>
<td>0.013</td>
<td>0.093</td>
<td>0.213</td>
<td>0.053</td>
<td>-0.030</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td>-0.780*</td>
<td>-0.668*</td>
<td>-0.626*</td>
<td>0.023</td>
<td>0.154</td>
<td>-0.443*</td>
<td>-0.068</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* denotes significance at 0.05 for a two-tailed test
### TABLE 9-3 (a)

**REGRESSION ANALYSIS FOR "INDUCTIVE REACTANCE" (X1)**

**DEPENDENT VARIABLE = POST-TEST 1 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R&lt;sup&gt;2&lt;/sup&gt;</th>
<th>ΔR&lt;sup&gt;2&lt;/sup&gt;</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRETEST</td>
<td>11.058 (0.002)</td>
<td>0.436</td>
<td>0.190</td>
<td>0.190</td>
<td>0.436</td>
<td>11.058 (0.002)</td>
<td>23.13 (SS)</td>
<td>4.841 (0.033)</td>
</tr>
<tr>
<td>2</td>
<td>D3</td>
<td>28.222 (0.001)</td>
<td>0.706</td>
<td>0.498</td>
<td>0.308</td>
<td>-0.689</td>
<td>22.842 (0.001)</td>
<td>37.496 (SS)</td>
<td>24.817 (0.001)</td>
</tr>
<tr>
<td>3</td>
<td>1STELL</td>
<td>3.703 (0.061)</td>
<td>0.732</td>
<td>0.536</td>
<td>0.038</td>
<td>0.184</td>
<td>17.357 (0.001)</td>
<td>4.626 (S)</td>
<td>0.776 (0.383)</td>
</tr>
<tr>
<td>4</td>
<td>FM</td>
<td>0.234 (0.631)</td>
<td>0.734</td>
<td>0.539</td>
<td>0.002</td>
<td>0.197</td>
<td>12.855 (0.001)</td>
<td>2.435 (NS)</td>
<td>1.329 (0.255)</td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>7.313 (0.010)</td>
<td>0.778</td>
<td>0.606</td>
<td>0.067</td>
<td>0.190</td>
<td>13.222 (0.001)</td>
<td>8.157 (SS)</td>
<td>9.512 (0.004)</td>
</tr>
<tr>
<td>6</td>
<td>D1</td>
<td>5.929 (0.013)</td>
<td>0.809</td>
<td>0.655&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.049</td>
<td>-0.247</td>
<td>13.270 (0.001)</td>
<td>5.929 (S)</td>
<td>5.929 (0.019)</td>
</tr>
</tbody>
</table>

<sup>a</sup> adjusted R<sup>2</sup> = 0.605
### TABLE 9-3 (b)

**REGRESSION ANALYSIS FOR "INDUCTIVE REACTANCE" (XI)**

**DEPENDENT VARIABLE = POST-TEST 1 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEPENDENT VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>3.057</td>
<td>0.247</td>
<td>0.061</td>
<td>0.061</td>
<td>-0.247</td>
<td>3.057</td>
<td>7.426</td>
<td>5.929</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.087)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.087)</td>
<td>(SS)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>2</td>
<td>PRETEST</td>
<td>12.292</td>
<td>0.509</td>
<td>0.259</td>
<td>0.198</td>
<td>0.436</td>
<td>8.041</td>
<td>24.104</td>
<td>4.841</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>3</td>
<td>D4</td>
<td>27.060</td>
<td>0.733</td>
<td>0.537</td>
<td>0.278</td>
<td>0.609</td>
<td>17.418</td>
<td>33.843</td>
<td>24.817</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>4</td>
<td>INTELL</td>
<td>3.550</td>
<td>0.756</td>
<td>0.572</td>
<td>0.035</td>
<td>0.185</td>
<td>14.691</td>
<td>4.261</td>
<td>0.776</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.066)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(S)</td>
<td>(0.383)</td>
</tr>
<tr>
<td>5</td>
<td>FM</td>
<td>0.468</td>
<td>0.759</td>
<td>0.576</td>
<td>0.005</td>
<td>0.397</td>
<td>11.705</td>
<td>0.609</td>
<td>1.329</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.497)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.255)</td>
</tr>
<tr>
<td>6</td>
<td>AGE</td>
<td>9.511</td>
<td>0.809</td>
<td>0.655*</td>
<td>0.078</td>
<td>-0.190</td>
<td>3.270</td>
<td>9.511</td>
<td>9.511</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.004)</td>
</tr>
</tbody>
</table>

\[\text{adjusted } R^2 = 0.605\]
9.3.1 Analysis of Post-Test 1 Contd.

As expected, previous experience (PE) is very significant accounting for about 30% of the variance in Post-test 1 when entered on the second or third steps. As pointed out earlier in Section 9.3, this is partly because the subjects who did not sit for the Pre-test were those with previous knowledge of the topic and the computer effectively read their Pre-test scores as zero, giving a greater net achievement for these subjects when Pre-test was adjusted for in the analysis. The ANOVA analysis had shown that previous experience was a significant factor in its own right, accounting for 40-45% of the variance when processed first.

As well as having had previous experience the subjects who did not sit for the Pre-test and who gained relatively high marks on Post-tests 1 and 2 were younger than the average with a mean age of 19.35, about one S.D. below the mean age for the entire population. Thus age also shows up as a significant predictor of performance on Post-test 1 after Pre-test is adjusted for and accounts for about 8% of the variance in the former when entered on the last step.

The above discussion serves to indicate the sensitivity of the experiment to relatively small changes in the values of the dependent variables and the necessity for careful and thoughtful interpretation of the results. It also indicates that the computer cannot do the researcher's thinking for him. Wherever possible independent checks should be made to ensure that the computer is processing the data according to specifications or requirements.

The method variable D1 is seen to account for about 5 to 6% of the variance in Post-test 1, a result in good agreement with that obtained using analysis of covariance (Table 3-2 (c)). $R^2$ is about 0.65, again in good agreement with the value of 0.68 obtained using analysis of variance, the small differences being due to differences in the way the two sub-programmes handle "missing data".

Moreover the value of $\Delta R^2$ is much the same for D1 whether it is processed first or last, supporting the assumption that interaction
9.3.1 Analysis of Post-Test 1 Contd.

Effects between method and other independent variables is negligible. When D1 is processed last $\Delta R^2$ measures its direct effects and takes the value of 0.049, whereas when D1 is processed first $\Delta R^2$ measures its total effects and takes the value of 0.061. The difference of $0.061 - 0.049 = 0.012$ is hardly worth further investigation.

In Tables 9-3(a) and 9-3(b) the significances of F3 are simply designated SS (meaning significant at the 0.01 level), S (meaning significant at the 0.05 level but not at the 0.01 level) or NS (meaning not significant at the 0.05 level) as these values have to be calculated by hand (See Section 5.3.2.1) and exact significant values are not therefore supplied automatically. The method variable D1 was significant at the 0.05 level through its direct effects and at the 0.01 level through its total effects (Table 9-3(b)).

It is interesting to note that the F3 value for intelligence is significant at the 0.05 level but the F4 value is not significant. The reason is that in the hierarchical procedure intelligence is taking up the indirect effects after all other independent variables have been allowed for (or "controlled").

The value of r for D1 is -0.247 indicating that the lecture-group performed more poorly or achieved less than the microfiche-group. Had D2 been processed instead of D1, r would have been +0.247. (One notes that in Table 9-3(a), r for D3 is -0.689 while in Table 9-3(b), r for the complementary dummy variable, D4, is +0.689).

Tables 9-3(c) and 9-3(d) show Post-test 1 results for the second topic in this series, "Capacitive Reactance", obtained from the REGRESSION sub-programme. Again the two sequences of independent variables described above are employed with the method variable being processed last and then first respectively. For this topic, all subjects bar one sat for the Pre-test and as his average Post-test score was only 12, his Pre-test score, had it been taken, would probably have been small. Thus no special interpretation of the
### TABLE 9-3 (c)

**REGRESSION ANALYSIS FOR "CAPACITIVE REACTANCE" (Xc)**

**DEPENDENT VARIABLE = POST-TEST \_SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRETEST</td>
<td>41.200 (0.001)</td>
<td>0.704</td>
<td>0.495</td>
<td>0.495</td>
<td>0.704</td>
<td>41.200 (0.001)</td>
<td>47.945 (SS)</td>
<td>1.144 (0.292)</td>
</tr>
<tr>
<td>2</td>
<td>D3</td>
<td>3.196 (0.081)</td>
<td>0.729</td>
<td>0.532</td>
<td>0.037</td>
<td>-0.668</td>
<td>23.275 (0.001)</td>
<td>3.584 (NS)</td>
<td>4.389 (0.043)</td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>1.093 (0.302)</td>
<td>0.738</td>
<td>0.544</td>
<td>0.012</td>
<td>0.161</td>
<td>15.916 (0.001)</td>
<td>1.162 (NS)</td>
<td>0.265 (0.610)</td>
</tr>
<tr>
<td>4</td>
<td>FM</td>
<td>6.660 (0.014)</td>
<td>0.781</td>
<td>0.611</td>
<td>0.066</td>
<td>0.621</td>
<td>15.291 (0.001)</td>
<td>6.393 (S)</td>
<td>7.106 (0.011)</td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>0.745 (0.393)</td>
<td>0.786</td>
<td>0.618</td>
<td>0.007</td>
<td>-0.023</td>
<td>12.302 (0.001)</td>
<td>0.678 (NS)</td>
<td>0.723 (0.401)</td>
</tr>
<tr>
<td>6</td>
<td>D2</td>
<td>0.000 (0.994)</td>
<td>0.786</td>
<td>0.618*</td>
<td>0.000</td>
<td>-0.013</td>
<td>9.982 (0.001)</td>
<td>0.000 (NS)</td>
<td>0.001 (0.994)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.571
<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>0.007 (0.933)</td>
<td>0.013</td>
<td>0.000</td>
<td>0.000</td>
<td>0.013</td>
<td>0.007 (0.933)</td>
<td>0.000 (NS)</td>
<td>0.001 (0.994)</td>
</tr>
<tr>
<td>2</td>
<td>PRETEST</td>
<td>40.485 (0.001)</td>
<td>0.705</td>
<td>0.497</td>
<td>0.497</td>
<td>0.704</td>
<td>20.249 (0.001)</td>
<td>48.139 (SS)</td>
<td>1.144 (0.292)</td>
</tr>
<tr>
<td>3</td>
<td>D3</td>
<td>2.982 (0.092)</td>
<td>0.729</td>
<td>0.532</td>
<td>0.035</td>
<td>-0.668</td>
<td>15.146 (0.001)</td>
<td>3.390 (NS)</td>
<td>4.389 (0.043)</td>
</tr>
<tr>
<td>4</td>
<td>INTELL</td>
<td>1.085 (0.304)</td>
<td>0.738</td>
<td>0.546</td>
<td>0.013</td>
<td>0.161</td>
<td>11.655 (0.001)</td>
<td>1.259 (NS)</td>
<td>0.265 (0.610)</td>
</tr>
<tr>
<td>5</td>
<td>FM</td>
<td>6.660 (0.015)</td>
<td>0.701</td>
<td>0.611</td>
<td>0.066</td>
<td>0.621</td>
<td>11.921 (0.001)</td>
<td>6.393 (SS)</td>
<td>7.106 (0.011)</td>
</tr>
<tr>
<td>6</td>
<td>AGE</td>
<td>0.723 (0.401)</td>
<td>0.786</td>
<td>0.618*</td>
<td>0.007</td>
<td>-0.023</td>
<td>9.982 (0.001)</td>
<td>0.723 (NS)</td>
<td>0.723 (0.401)</td>
</tr>
</tbody>
</table>

* adjusted $R^2 = 0.571$
3.1 Analysis of Post-Test Contd.

It is required to account for the possible effects of "missing data" and a direct comparison can be made with the ANOVA results reported in Section 9.2.1.

From Table 9-3 (d) we see that for Xc method effects are nearly non-existent even when the method variables are processed first. This agrees with the results obtained with the ANOVA sub-programme where $\eta^2$ was 0.002 with FM included as a covariate (Table 9-2 (c)). Method is having no direct effect and nor is it acting through any of the other dependent variables.

The values of $F_4$ cannot be directly compared with those for Topic 28 in Table 9-2 (b) for the covariates, as the latter were evaluated before the processing of the factors (method and previous experience). If factors are exerting only a small influence the difference will not be great. However here, previous experience is significant or nearly so, after all other variables are accounted for and, for the covariates in Table 9-2 (b), $F$ will be greater than for $F_4$ as given in Tables 9-2 (d) and 9-2 (e).

For previous experience, however, the value of $F_4$ in Tables 9-3 (c) and 9-3 (d), 4.389 is nearly the same as that in Table 9-2 (b), 4.002, the discrepancy being due to the slightly differing populations.

In Table 9-3 (c) previous experience only accounts for about 4% of the variance in the dependent variable when entered on step two. Table 9-2 (c), on the other hand, gives a $\eta^2$ of 0.476 indicating that the proportion of variance explained by previous experience is about 48%. The discrepancy, of course, arises because the value of $\eta^2$ is calculated from the simple correlation coefficient whereas $\Delta R^2$ will depend upon the multiple correlation coefficient $R$ at any given step or stage in the analysis.

$R^2$ from Tables 9-2 (d) and 9-2 (e) is 0.618, almost the same as the value of $R^2$ obtained from the ANOVA sub-programme for Topic 28 (Table 9-2 (c)).
9.3.1 Analysis of Post-Test 1 Contd.

For X1 the Pre-test was still significant after all other independent variables had been processed. However for Xc the Pre-test is having little effect after all other independent variables are processed, F4 being only 1.144. Of course, when Pre-test is processed first, using the hierarchical procedure, its F value, as measured by F3, is much greater, 47.945. It is interesting to note that Table 9-2 (o) indicates that Pre-test is still highly significant for Topic 2B, if only other covariates are adjusted for, although final mark is now a much more important covariate than for X1.

.2 Analysis of Post-test 2

Tables 9-4 (a) and 9-4 (b) summarize the multiple regression results for "Inductive Reactance" with Post-test 2 as the dependent variable. As for Post-test 1, two sequences of independent variables were processed one with the method variables first and the other with them last.

As expected method is now exerting virtually no effect, the method effects from the instructional period, which were significant, having been taken up by the Post-test 1. Even when processed first, method only accounts for about 1% of the variance in Post-test 2.

As all 49 subjects sat for both Post-tests 1 and 2 there are no "missing data" complications in interpreting Tables 9-4 (a) and 9-4 (b). Thus age has faded out as a significant source of variance and previous experience, although still significant, only accounts for about 6% of the variance when entered on step two, after Pre-test compared to 30% for Post-test 1 (Table 9-3 (a)). From Table 9-2 (f) \( \eta^2 \) is 0.449 for previous experience, this being the overall variance accounted for by previous experience, i.e. the value of \( \Delta R^2 \) were it to be entered on the first step.

From Table 9-2 (f) \( R^2 \) is 0.717 for Topic 2 which is in close agreement with the value of 0.682 obtained from Tables 5-4 (a) and 9-4 (b) using the ANOVA sub-programme.
TABLE 9-4 (a)

REGRESSION ANALYSIS FOR "INDUCTIVE REACTANCE" (X1)

DEPENDENT VARIABLE = POST-TEST 2 SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1 (df)</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2 (df)</th>
<th>F3 (df)</th>
<th>F4 (df)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POST-TEST 1</td>
<td>47.679  (0.001)</td>
<td>0.710</td>
<td>0.504</td>
<td>0.504</td>
<td>0.710</td>
<td>47.679  (0.001)</td>
<td>58.642  (SS)</td>
<td>5.493  (0.024)</td>
</tr>
<tr>
<td>2</td>
<td>D3</td>
<td>6.672  (0.013)</td>
<td>0.753</td>
<td>0.566</td>
<td>0.063</td>
<td>-0.671</td>
<td>30.052  (0.001)</td>
<td>7.330  (S)</td>
<td>4.900  (0.032)</td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>0.094  (0.761)</td>
<td>0.753</td>
<td>0.567</td>
<td>0.001</td>
<td>0.131</td>
<td>19.671  (0.001)</td>
<td>0.116  (NS)</td>
<td>0.220  (0.641)</td>
</tr>
<tr>
<td>4</td>
<td>FM</td>
<td>12.466 (0.001)</td>
<td>0.814</td>
<td>0.663</td>
<td>0.096</td>
<td>0.671</td>
<td>21.629  (0.001)</td>
<td>11.170  (SS)</td>
<td>14.054  (0.001)</td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>2.531  (0.119)</td>
<td>0.826</td>
<td>0.682</td>
<td>0.019</td>
<td>-0.124</td>
<td>18.412  (0.001)</td>
<td>2.211  (NS)</td>
<td>2.487  (0.122)</td>
</tr>
<tr>
<td>6</td>
<td>D1</td>
<td>0.936  (0.851)</td>
<td>0.826</td>
<td>0.682</td>
<td>0.000</td>
<td>-0.095</td>
<td>15.005  (0.001)</td>
<td>0.036  (NS)</td>
<td>0.036  (0.851)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.645
TABLE 9-4 (b)
REGRESSION ANALYSIS FOR "INDUCTIVE REACTANCE" (X1)
DEPENDENT VARIABLE = POST-TEST 2 SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEPENDENT VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>0.426</td>
<td>0.095</td>
<td>0.009</td>
<td>0.009</td>
<td>-0.059</td>
<td>0.426</td>
<td>1.047</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>(0.517)</td>
<td></td>
<td>(0.517)</td>
<td>(NS)</td>
<td>(0.851)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>POST-TEST 1</td>
<td>47.129</td>
<td>0.714</td>
<td>0.511</td>
<td>0.502</td>
<td>0.710</td>
<td>23.986</td>
<td>58.409</td>
<td>5.493</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>D3</td>
<td>6.173</td>
<td>0.755</td>
<td>0.570</td>
<td>0.059</td>
<td>-0.671</td>
<td>19.847</td>
<td>6.865</td>
<td>4.900</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td></td>
<td>(0.017)</td>
<td>(S)</td>
<td>(0.032)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>INTELL</td>
<td>0.096</td>
<td>0.755</td>
<td>0.570</td>
<td>0.001</td>
<td>0.131</td>
<td>14.611</td>
<td>0.116</td>
<td>0.220</td>
</tr>
<tr>
<td></td>
<td>(0.758)</td>
<td></td>
<td>(0.758)</td>
<td>(NS)</td>
<td>(0.641)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>FM</td>
<td>11.814</td>
<td>0.814</td>
<td>0.663</td>
<td>0.093</td>
<td>0.617</td>
<td>16.924</td>
<td>10.821</td>
<td>14.054</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>AGE</td>
<td>2.487</td>
<td>0.826</td>
<td>0.682</td>
<td>0.019</td>
<td>-0.124</td>
<td>15.005</td>
<td>2.211</td>
<td>2.487</td>
</tr>
<tr>
<td></td>
<td>(0.122)</td>
<td></td>
<td>(0.122)</td>
<td>(NS)</td>
<td>(0.122)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* adjusted R² = 0.645
9.3.2 Analysis of Post-test 2 Contd.

As found in the ANOVA analysis, final mark is now very significant. Table 9-4 (a) shows that it accounts for nearly 10% of the variance even when processed after Post-test 1 score and intelligence. In the analysis of Post-test 1, it accounted for less than 1% of the variance when entered at the same step.

Tables 9-4 (c) and 9-4 (d) summarize the multiple regression results for "Capacitve Reactance" with Post-test 2 as the dependent variable.

Again method is quite insignificant whether it is processed first or last. As found with the ANOVA sub-programme, previous experience is not significant only accounting for about 1% of the variance when entered on the second step in Table 9-4 (c), compared to about 6% for X1.

Also as found in the ANOVA analysis, final mark, FM, is again significant but Post-test 1 is by far the most important source of variance in the dependent variable, whether it is entered first or last (see appropriate F3 and F4 values).

The $R^2$ value of 0.768 obtained from Tables 9-4 (c) and 9-4 (d) is in good agreement with the value of 0.778 obtained from Table 9-2 (f) for Topic 28.

The discussion already presented in Section 9.2.2 will not be repeated here. However, it is clear that teaching method is having virtually no effect upon performance on Post-test 2. No differential retention rates were apparent from the analyses. This does not mean than such an effect would not show up were the period between Post-tests 1 and 2 to be lengthened or instruction via the two methods extended to cover several periods.

4 Time Considerations

For convenience we will discuss the times taken by the subjects on both topics together. For other discussions of time considerations and self-paced learning the reader is also referred to the relevant sections in Section 8.
<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POST-TEST 1</td>
<td>99.355</td>
<td>0.838</td>
<td>0.703</td>
<td>0.703</td>
<td>0.838</td>
<td>99.354</td>
<td>112.12</td>
<td>23.841</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>2</td>
<td>D3</td>
<td>1.091</td>
<td>0.843</td>
<td>0.711</td>
<td>0.008</td>
<td>-0.626</td>
<td>50.330</td>
<td>1.276</td>
<td>0.983</td>
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<tr>
<td></td>
<td></td>
<td>(0.302)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(NS)</td>
<td>(0.328)</td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>0.170</td>
<td>0.844</td>
<td>0.721</td>
<td>0.001</td>
<td>0.086</td>
<td>32.931</td>
<td>0.159</td>
<td>1.872</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.682)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(NS)</td>
<td>(0.180)</td>
</tr>
<tr>
<td>4</td>
<td>FM</td>
<td>3.993</td>
<td>0.859</td>
<td>0.739</td>
<td>0.027</td>
<td>0.648</td>
<td>27.544</td>
<td>4.306</td>
<td>6.240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.053)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(SS)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>2.538</td>
<td>0.869</td>
<td>0.755</td>
<td>0.016</td>
<td>-0.079</td>
<td>23.412</td>
<td>2.552</td>
<td>3.094</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.119)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(NS)</td>
<td>(0.087)</td>
</tr>
<tr>
<td>6</td>
<td>D2</td>
<td>2.060</td>
<td>0.876</td>
<td>0.768*</td>
<td>0.013</td>
<td>-0.093</td>
<td>20.400</td>
<td>2.060</td>
<td>2.250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.160)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(0.160)</td>
<td>(0.160)</td>
</tr>
</tbody>
</table>

* adjusted $R^2 = 0.730$
TABLE 9-4 (d)

REGRESSION ANALYSIS FOR "CAPACITIVE REACTANCE" (Xc)

DEPENDENT VARIABLE = POST-TEST 2 SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>0.363</td>
<td>0.093</td>
<td>0.009</td>
<td>0.009</td>
<td>0.093</td>
<td>0.363</td>
<td>1.435</td>
<td>2.060</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.550)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td></td>
<td>(NS)</td>
</tr>
<tr>
<td>2</td>
<td>POST-TEST 1</td>
<td>98.942</td>
<td>0.842</td>
<td>0.710</td>
<td>0.701</td>
<td>0.838</td>
<td>50.075</td>
<td>111.797</td>
<td>23.841</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td></td>
<td>(SS)</td>
</tr>
<tr>
<td>3</td>
<td>D3</td>
<td>0.936</td>
<td>0.846</td>
<td>0.716</td>
<td>0.007</td>
<td>-0.626</td>
<td>33.644</td>
<td>1.116</td>
<td>0.983</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.339)</td>
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<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td></td>
<td>(0.328)</td>
</tr>
<tr>
<td>4</td>
<td>INTELL</td>
<td>0.404</td>
<td>0.843</td>
<td>0.719</td>
<td>0.003</td>
<td>0.086</td>
<td>24.958</td>
<td>0.478</td>
<td>1.872</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.529)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td></td>
<td>(0.180)</td>
</tr>
<tr>
<td>5</td>
<td>FM</td>
<td>4.435</td>
<td>0.865</td>
<td>0.748</td>
<td>0.029</td>
<td>0.648</td>
<td>22.612</td>
<td>4.625</td>
<td>6.240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.042)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(S)</td>
<td></td>
<td>(0.017)</td>
</tr>
<tr>
<td>6</td>
<td>AGE</td>
<td>3.094</td>
<td>0.876</td>
<td>0.768</td>
<td>0.019</td>
<td>-0.079</td>
<td>20.397</td>
<td>3.094</td>
<td>3.094</td>
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<tr>
<td></td>
<td></td>
<td>(0.087)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td></td>
<td>(0.087)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.730
9.4.1 Comparison of Instructional Periods

Table 9-5 lists the instructional periods spent by the stage 1 part-time science class for the topics "Inductive Reactance" and "Capacitive Reactance".

### Table 9-5

**Comparison of Instructional Periods**

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>LECTURE (MINUTES)</th>
<th>MICROFICHE (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xi Mean</td>
<td>50</td>
<td>50.14</td>
</tr>
<tr>
<td>S.D.</td>
<td>-</td>
<td>9.57</td>
</tr>
<tr>
<td>Variance</td>
<td>-</td>
<td>91.65</td>
</tr>
<tr>
<td>(N = 22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xc Mean</td>
<td>50</td>
<td>51.17</td>
</tr>
<tr>
<td>S.D.</td>
<td>-</td>
<td>14.23</td>
</tr>
<tr>
<td>Variance</td>
<td>-</td>
<td>202.58</td>
</tr>
<tr>
<td>(N = 24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVER-</td>
<td>Mean</td>
<td>50</td>
</tr>
<tr>
<td>ALL</td>
<td>S.D.</td>
<td>50.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.11</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>146.58</td>
</tr>
<tr>
<td></td>
<td>(N = 46)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 9-2 shows graphically the distributions of times taken on the two topics and compares them with the theoretical overall normal distribution i.e. that with a mean of 50.67 and a S.D. of 12.11. Figure 9-3 compares the theoretical overall distribution with the average distribution for all self-paced subjects. Over a distance of ± 2 S.D. from the mean, the differences between the two distributions are not significant to the 0.05 level (two-tailed test).

We see from Figure 9-3 that more subjects finish the programme after approximately one hour than we would expect for an exactly normal distribution. One reason is apparently because the slower students race against the clock and finish sooner than would be the case in a fully self-paced situation.
Fig. 9-3
Times taken by
Stage One Science

Percentage Finishing

- Theoretical or Normal Distribution
- Observed Distribution

Lecture
Mean of self-paced group

Minutes
9.4.1 **Comparison of Instructional Periods Contd.**

Indicates that a similar phenomena may have occurred with the Stage 1 Mathematics class.

For these experiments the lecture had nearly the same duration as the mean time spent on the self-paced programmes. Thus although the lecturer had correctly gauged the requirements of the "average student", a great many had a "natural speed" either substantially more or less than the average.

.2 **Analysis of Times Taken by Self-Paced Subjects on Stage 1 Science Topics**

In this Section we will follow the same approach as that adopted in Section 8.1.3.2 for the Preparatory Mathematics class. The total number of self-paced subjects, including those for both X1 and Xc, was 46 which is sufficient for a reasonably reliable statistical analysis using both of our major statistical procedures.

We saw that, for the Preparatory Mathematics class, time taken at self-paced instruction becomes an insignificant factor in determining Post-test scores after Pre-test scores and intelligence are controlled. Is this result replicated for the Stage 1 Science class as well?

While multiple regression analysis is ideally suited to this investigation, we will first discuss results obtained using the SPSS ANOVA sub-programme.

.1 **Analysis of Covariance**

Here we are concerned not with time taken, per se, but with how time taken affects scores on the Post-tests. Thus we will use time taken or "TT" as an independent variable and, as before, Post-test scores as the dependent variable.

Tables 9-6 (a) to (f) show the results obtained for four SPSS ANOVA runs. As those subjects who did not sit for the Pre-test are excluded, the effective sample size is 40 for the analysis of Post-test 1. The runs are as follows:
TABLE 9-6 (a)

ANALYSIS OF POST-TEST I FOR SELF-PACED SUBJECTS ON BOTH STAGE 1 TOPICS TOGETHER
(N = 40)

SIGNIFICANCE OF F VALUES

<table>
<thead>
<tr>
<th>RUN</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>TT</th>
<th>TOPIC</th>
<th>PE</th>
<th>TOPIC X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.001</td>
<td>0.723</td>
<td>0.739</td>
<td>0.951</td>
<td>0.775</td>
<td>0.124</td>
<td>0.867</td>
</tr>
<tr>
<td>2</td>
<td>0.001</td>
<td>-</td>
<td>0.754</td>
<td>0.998</td>
<td>0.803</td>
<td>0.100</td>
<td>0.850</td>
</tr>
</tbody>
</table>
### Table 9-6 (b)

**Analysis of Post-Test 1 for Self-Paced Subjects on Both Stage 1 Topics Together**

(N = 40)

**F Values**

<table>
<thead>
<tr>
<th>Run</th>
<th>Pretest</th>
<th>Intell</th>
<th>Age</th>
<th>TT</th>
<th>Topic</th>
<th>PE</th>
<th>Topic X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.587</td>
<td>0.128</td>
<td>0.113</td>
<td>0.004</td>
<td>0.083</td>
<td>2.496</td>
<td>0.028</td>
</tr>
<tr>
<td>2</td>
<td>25.310</td>
<td>-</td>
<td>0.100</td>
<td>0.000</td>
<td>0.063</td>
<td>2.858</td>
<td>0.036</td>
</tr>
</tbody>
</table>
TABLE 9-6 (c)

ANALYSIS OF POST-TEST 1 FOR SELF-PACED SUBJECTS ON BOTH STAGE 1 TOPICS TOGETHER
(N = 46)

VALUES OF ETA, BETA AND MULTIPLE R*

<table>
<thead>
<tr>
<th>RUN</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TOPIC**</td>
<td>0.11</td>
<td>0.05</td>
<td>0.706</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.012)</td>
<td>(0.003)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PE***</td>
<td>0.63</td>
<td>0.36</td>
<td>(0.499)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.397)</td>
<td>(0.130)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TOPIC</td>
<td>0.11</td>
<td>0.04</td>
<td>0.706</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.012)</td>
<td>(0.002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>0.63</td>
<td>0.37</td>
<td>(0.498)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.397)</td>
<td>(0.137)</td>
<td></td>
</tr>
</tbody>
</table>

* squares of values are shown in brackets
** two topics for each run
*** two categories for each run
### TABLE 9-6 (d)

**Analysis of Post-Test 2 for Self-Paced Subjects on Both Stage 1 Topics Together**  
\(N = 46\)

**Significance of F Values**

<table>
<thead>
<tr>
<th>RUN</th>
<th>POST-TEST 1</th>
<th>INTELL</th>
<th>AGE</th>
<th>TT</th>
<th>TOPIC</th>
<th>PE</th>
<th>TOPIC X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.001</td>
<td>0.391</td>
<td>0.408</td>
<td>0.150</td>
<td>0.674</td>
<td>0.026</td>
<td>0.214</td>
</tr>
<tr>
<td>4</td>
<td>0.001</td>
<td>-</td>
<td>0.345</td>
<td>0.198</td>
<td>0.806</td>
<td>0.023</td>
<td>0.571</td>
</tr>
</tbody>
</table>

### TABLE 9-6 (e)

**Analysis of Post-Test 2 for Self-Paced Subjects on Both Stage 1 Topics Together**  
\(N = 46\)

**F Values**

<table>
<thead>
<tr>
<th>RUN</th>
<th>POST-TEST 1</th>
<th>INTELL</th>
<th>AGE</th>
<th>TT</th>
<th>TOPIC</th>
<th>PE</th>
<th>TOPIC X PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>36.512</td>
<td>0.752</td>
<td>0.700</td>
<td>2.162</td>
<td>0.180</td>
<td>5.336</td>
<td>0.646</td>
</tr>
<tr>
<td>4</td>
<td>37.499</td>
<td>-</td>
<td>0.913</td>
<td>1.718</td>
<td>0.061</td>
<td>5.633</td>
<td>0.327</td>
</tr>
</tbody>
</table>
### TABLE 9-6 (f)

**ANALYSIS OF POST-TEST 2 FOR SELF-PACED SUBJECTS ON BOTH STAGE 1 TOPICS TOGETHER**  
*(N = 46)*

**VALUES OF ETA, BETA AND MULTIPLF R**

<table>
<thead>
<tr>
<th>RUN</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>TOPIC**</td>
<td>0.05</td>
<td>0.05</td>
<td>0.759</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PE***</td>
<td>0.64</td>
<td>0.33</td>
<td>(0.576)</td>
</tr>
<tr>
<td></td>
<td>(0.410)</td>
<td>(0.109)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>TOPIC</td>
<td>0.05</td>
<td>0.03</td>
<td>0.754</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>0.64</td>
<td>0.34</td>
<td>(0.568)</td>
</tr>
<tr>
<td></td>
<td>(0.410)</td>
<td>(0.116)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* squares of values are shown in brackets  
** two topics for each run  
*** two categories for each run
9.4.2.1 Analysis of Covariance Contd.

(1) Post-test 1 as dependent variable with topic, previous experience ("PE"), Pre-test, intelligence, age and TT as independent variables.

(2) Post-test 1 as dependent variable with the same independent variables as for (1) except with intelligence omitted.

(3) Post-test 2 as dependent variable with topic, previous experience, Pre-test 1, intelligence, age and TT as independent variables.

(4) Post-test 2 as dependent variable with the same independent variables as for (3) except with intelligence omitted.

The Post-test 1 and 2 scores are now taken over two topics and so "topic" is introduced as an independent variable. As 46 separate subjects were involved overall, the fixed effects model assumed by the ANOVA sub-programme (as well as by the REGRESSION sub-programme), is not affected.

The F values for each covariate in Table 9-6 (b) are calculated it will be recalled, as if the covariate was processed after all other covariates. Thus time taken (TT) is having nearly zero effect upon Post-test 1 after the other covariates are processed. Intelligence itself is seen to be having little effect and it makes little difference to the analysis whether it is included or not.

For the self-paced subjects Pre-test score is thus the main source of variance in the Post-test 1 score and time taken has negligible effect. PE, or previous experience, is having some effect but it is not significant at the 0.05 level. Topic also is having no effect, once Pre-test scores are accounted for.

For Post-test 2, time taken is still insignificant but previous experience seems to be a more important factor for the complete population of subjects than for the self-paced group alone, especially in Post-test 1 (see Table 9-2 (a)).

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9.4.2.2 Multiple Regression Analysis

It will be recalled that the SPSS REGRESSION sub-program substitutes the value of zero for missing data rather than excluding the relevant case from the analysis.

Thus for reasons explained in Section 9.4, care is therefore required in interpreting the multiple regression results for Post-test 1 as the effects of previous experience and age (most of the missing data were for younger subjects with previous experience) will be enhanced.

Nevertheless it is informative to carry out an analysis on the 46 available subjects from both the X1 and Xc microfich programmes together, with the two sequences of independent variables as follows:

1. D1, D2 (Previous Experience)
2. Pre-test (or Post-test 1)
3. Intelligence
4. D3, D4 (Topic)
5. Age
6. TT

and

1. TT
2. D1, D2 (Previous Experience)
3. Pre-test (or Post-test 1)
4. Intelligence
5. D3, D4 (Topic)
6. Age

Method, of course, is no longer a factor and D1 and D2 now represent dummy variables for previous experience. D1 to D4 were created by the appropriate control statements thus:

IF (PE EQ 0) D1 = 1
IF (PE EQ 1) D2 = 1
IF (TOPIC EQ 1) D3 = 1
IF (TOPIC EQ 2) D4 = 1

(see Sections 5.3.12 and 9.4 for a fuller discussion of what these statements mean).
Multiple Regression Analysis Contd.

Tables 9-7 (a) to 9-7 (d) summarize the multiple regression results for both Post-tests 1 and 2 using the hierarchical procedure to enter the independent variables in the two sequential orders. Table 9-7 (e) gives the correlation matrix relating TT to other variables.

Tables 9-7 (a) and 9-7 (c) show that time taken (TT) is having no significant effect when processed last. Thus its "direct effect" upon the dependent variable is nil or marginal. On the other hand Tables 9-7 (b) and 9-7 (d) show that TT becomes a significant predictor of Post-test 1 score when processed first.

We would expect this of course, as when entered on step 1, the total effect of the variable will show up as no adjustments have been made for other independent variables. It is interesting to see that under these conditions TT exerts slightly more influence upon the Post-test 2 than upon Post-test 1. A possible reason is because TT is associated with other variables such as motivation which became more important during the intervening period. Whatever the reason the effect becomes significant when adjustments are made for other independent variables.

As the simple correlation between TT and the dependent variable is negative, the slower subjects perform more poorly than the faster subjects. The slower students are apparently older and less bright than the average and they performed poorly also on the Pre-test or/and Post-test 1. (See Table 9-7 (e) for table of simple correlation coefficients).

Previous experience is very significant for both Post-tests 1 and 2 when entered on the first step and when entered last (as indicated by the relevant F values). The latter is in agreement with Table 9-6 (d) but the significance on the last step does not agree with Table 9-6 (a) because of the differences in populations discussed in Section 9.3.

From Table 9-7 (c) $R^2$ for D1 is 0.414 which is in good agreement with the value of 0.397 obtained from Table 9-6 (c) for eta².
### TABLE 9-7 (a)

**REGRESSION ANALYSIS FOR SELF-PACED SUBJECTS**

**TOPIC:** XI and Xc

**DEPENDENT VARIABLE = POST-TEST 1 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>27.556</td>
<td>0.621</td>
<td>0.385</td>
<td>0.385</td>
<td>-0.621</td>
<td>27.556</td>
<td>29.851</td>
<td>8.491</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td>(0.006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PRETEST</td>
<td>5.246</td>
<td>0.672</td>
<td>0.452</td>
<td>0.067</td>
<td>0.561</td>
<td>17.731</td>
<td>5.195</td>
<td>3.152</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td>(0.027)</td>
<td></td>
<td>(0.084)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>INTELL</td>
<td>0.114</td>
<td>0.673</td>
<td>0.453</td>
<td>0.001</td>
<td>0.035</td>
<td>11.615</td>
<td>0.078</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>(0.737)</td>
<td></td>
<td></td>
<td></td>
<td>(0.737)</td>
<td></td>
<td>(0.800)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D3</td>
<td>0.182</td>
<td>0.675</td>
<td>0.456</td>
<td>0.002</td>
<td>0.031</td>
<td>8.587</td>
<td>0.155</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>(0.672)</td>
<td></td>
<td></td>
<td></td>
<td>(0.672)</td>
<td></td>
<td>(0.178)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>2.944</td>
<td>0.702</td>
<td>0.493</td>
<td>0.037</td>
<td>-0.148</td>
<td>7.784</td>
<td>2.869</td>
<td>1.882</td>
</tr>
<tr>
<td></td>
<td>(0.094)</td>
<td></td>
<td></td>
<td></td>
<td>(0.094)</td>
<td></td>
<td>(0.178)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>TT</td>
<td>0.299</td>
<td>0.705</td>
<td>0.497*</td>
<td>0.004</td>
<td>-0.271</td>
<td>6.423</td>
<td>0.310</td>
<td>0.299</td>
</tr>
<tr>
<td></td>
<td>(0.587)</td>
<td></td>
<td></td>
<td></td>
<td>(0.587)</td>
<td></td>
<td>(0.587)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*adjusted $R^2 = 0.420$
### Table 9-7 (b)

Regression Analysis for Self-Paced Subjects

**Dependent Variable: Post-Test 1 Score**

<table>
<thead>
<tr>
<th>Step</th>
<th>Independent Variable</th>
<th>F1</th>
<th>R</th>
<th>R^2</th>
<th>ΔR^2</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TT</td>
<td>3.485 (0.069)</td>
<td>0.271</td>
<td>0.073</td>
<td>0.073</td>
<td>-0.271</td>
<td>3.485 (0.069)</td>
<td>5.660 (5)</td>
<td>0.299 (0.587)</td>
</tr>
<tr>
<td>2</td>
<td>D2</td>
<td>25.333 (0.001)</td>
<td>0.646</td>
<td>0.417</td>
<td>0.344</td>
<td>0.621</td>
<td>15.373 (0.001)</td>
<td>26.672 (5S)</td>
<td>8.491 (0.006)</td>
</tr>
<tr>
<td>3</td>
<td>PRETEST</td>
<td>4.303 (0.044)</td>
<td>0.686</td>
<td>0.471</td>
<td>0.054</td>
<td>0.561</td>
<td>12.470 (0.001)</td>
<td>4.187 (5)</td>
<td>3.152 (0.084)</td>
</tr>
<tr>
<td>4</td>
<td>INTELL</td>
<td>0.000 (0.985)</td>
<td>0.686</td>
<td>0.471</td>
<td>0.000</td>
<td>0.035</td>
<td>9.130 (0.001)</td>
<td>0.000 (NS)</td>
<td>0.065 (0.800)</td>
</tr>
<tr>
<td>5</td>
<td>D3</td>
<td>0.125 (0.725)</td>
<td>0.688</td>
<td>0.473</td>
<td>0.002</td>
<td>0.031</td>
<td>7.173 (0.001)</td>
<td>0.155 (NS)</td>
<td>0.135 (0.716)</td>
</tr>
<tr>
<td>6</td>
<td>AGE</td>
<td>1.883 (0.178)</td>
<td>0.705</td>
<td>0.497*</td>
<td>0.024</td>
<td>-0.148</td>
<td>6.423 (0.001)</td>
<td>1.883 (NS)</td>
<td>1.883 (0.178)</td>
</tr>
</tbody>
</table>

*Adjusted $R^2 = 0.407$
### TABLE 9-7 (c)

**REGRESSION ANALYSIS FOR SELF-PACED SUBJECTS**

**DEPENDENT VARIABLE = POST-TEST 2 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>31.022 (0.001)</td>
<td>0.643</td>
<td>0.414</td>
<td>0.414</td>
<td>-0.643</td>
<td>31.022 (0.001)</td>
<td>38.080 (SS)</td>
<td>5.446 (0.025)</td>
</tr>
<tr>
<td>2</td>
<td>POST-TEST 1</td>
<td>13.560 (0.001)</td>
<td>0.744</td>
<td>0.554</td>
<td>0.141</td>
<td>0.693</td>
<td>26.719 (0.001)</td>
<td>12.969 (SS)</td>
<td>10.321 (0.003)</td>
</tr>
<tr>
<td>3</td>
<td>IXTELL</td>
<td>0.233 (0.632)</td>
<td>0.746</td>
<td>0.557</td>
<td>0.002</td>
<td>-0.042</td>
<td>17.572 (0.001)</td>
<td>0.184 (NS)</td>
<td>0.788 (0.380)</td>
</tr>
<tr>
<td>4</td>
<td>D3</td>
<td>0.181 (0.673)</td>
<td>0.747</td>
<td>0.559</td>
<td>0.002</td>
<td>-0.052</td>
<td>12.967 (0.001)</td>
<td>0.184 (NS)</td>
<td>0.788 (0.380)</td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>0.155 (0.696)</td>
<td>0.748</td>
<td>0.560</td>
<td>0.002</td>
<td>-0.051</td>
<td>10.191 (0.001)</td>
<td>0.184 (NS)</td>
<td>0.184 (0.670)</td>
</tr>
<tr>
<td>6</td>
<td>TT</td>
<td>1.494 (0.229)</td>
<td>0.759</td>
<td>0.576*</td>
<td>0.016</td>
<td>-0.291</td>
<td>8.846 (0.001)</td>
<td>1.494 (NS)</td>
<td>1.494 (0.229)</td>
</tr>
</tbody>
</table>

* adjusted $R^2 = 0.511$
### TABLE 9-7 (d)

**REGRESSION ANALYSIS FOR SELF-PACED SUBJECTS**

**DEPENDENT VARIABLE = POST-TEST 2 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TT</td>
<td>4.082 (0.049)</td>
<td>0.291</td>
<td>0.085</td>
<td>0.085</td>
<td>-0.291</td>
<td>4.082 (0.001)</td>
<td>7.818 (SS)</td>
<td>1.494 (0.229)</td>
</tr>
<tr>
<td>2</td>
<td>D2</td>
<td>28.775 (0.021)</td>
<td>0.672</td>
<td>0.452</td>
<td>0.367</td>
<td>0.643</td>
<td>17.717 (0.001)</td>
<td>33.757 (SS)</td>
<td>5.446 (0.025)</td>
</tr>
<tr>
<td>3</td>
<td>POST-TEST 1</td>
<td>11.171 (0.002)</td>
<td>0.753</td>
<td>0.567</td>
<td>0.115</td>
<td>0.693</td>
<td>18.329 (0.001)</td>
<td>10.578 (SS)</td>
<td>10.321 (0.003)</td>
</tr>
<tr>
<td>4</td>
<td>INTELL</td>
<td>0.718 (0.402)</td>
<td>0.758</td>
<td>0.574</td>
<td>0.007</td>
<td>-0.042</td>
<td>13.834 (0.001)</td>
<td>0.633 (NS)</td>
<td>0.788 (0.380)</td>
</tr>
<tr>
<td>5</td>
<td>D3</td>
<td>0.190 (0.665)</td>
<td>0.759</td>
<td>0.576</td>
<td>0.002</td>
<td>-0.052</td>
<td>10.887 (0.001)</td>
<td>0.184 (NS)</td>
<td>0.184 (0.670)</td>
</tr>
<tr>
<td>6</td>
<td>AGE</td>
<td>0.003 (0.957)</td>
<td>0.759</td>
<td>0.576*</td>
<td>0.000</td>
<td>-0.051</td>
<td>8.846 (0.001)</td>
<td>0.003 (NS)</td>
<td>0.003 (0.957)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.511
### Table 8-7 (a)

**Table of Correlation Coefficients for Self-Paced Subjects**

\( n = 19 \)

<table>
<thead>
<tr>
<th></th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>AGE</th>
<th>INTELL</th>
<th>D1</th>
<th>D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-TEST 1</td>
<td>0.561*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST-TEST 2</td>
<td>0.557*</td>
<td>0.693*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>-0.048</td>
<td>-0.148</td>
<td>-0.051</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTELL</td>
<td>0.032</td>
<td>0.035</td>
<td>-0.042</td>
<td>-0.223</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>-0.599*</td>
<td>-0.621*</td>
<td>-0.643*</td>
<td>-0.136</td>
<td>0.029</td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td>0.401*</td>
<td>0.031</td>
<td>-0.052</td>
<td>-0.033</td>
<td>-0.200</td>
<td>-0.10*</td>
</tr>
<tr>
<td>TT</td>
<td>-0.218</td>
<td>-0.271*</td>
<td>-0.291*</td>
<td>0.398*</td>
<td>-0.291</td>
<td>0.152</td>
</tr>
</tbody>
</table>

* denotes significance at 0.05 level for a two-tailed test
9.5 Predictors of the Final Mark for Stage 1 Science

Although not directly related to the objectives of the research it was a worthwhile exercise to look for the most important predictors of final mark, FM, from the data available.*

Table 9-8 (a) shows the results of a multiple regression analysis using selected independent variables on the 49 subjects who participated in the experiment for X1.

Table 9-8 (b) shows the results of a similar analysis carried out on the 43 subjects who participated in the experiment for Xc and for whom final mark scores were known.

The results for Tables 9-8 (a) and 9-8 (b) are very similar as one would also expect from the similarities in Tables 9-2 (g) and 9-2 (h).

The dummy variables entered into the analysis were defined by the control statements:

IF (METHOD EQ 1) D1 = 1 ("lecture")
IF (METHOD EQ 2) D2 = 1 ("microfiche")
IF (PE EQ 0) D3 = 1 ("no previous experience")
IF (PE EQ 1) D4 = 1 ("previous experience")

(The second and fourth, or first and third IF statements are optional).

Method, of course, would not be expected to be significant, as microfiche was only used for one instructional period by each student. The table confirms this expectation.

Previous experience is very significant when processed first but fades out as a significant factor when the other independent variables are processed beforehand (statistic F4). The Post-test 2 score is very significant whether processed on step 3 or last, while age for X1, is nearly significant when processed on step 4 and is significant when processed last. Intelligence is not significant when processed after previous experience (and before Post-test 2 and age) or when processed last.

* FM is for the Stage One Science Course only.
TABLE 9-8 (a)

REGRESSION ANALYSIS FOR STAGE 1 SCIENCE (X1)

DEPENDENT VARIABLE = FM

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEPENDENT VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D3</td>
<td>11.674</td>
<td>0.446</td>
<td>0.199</td>
<td>0.199</td>
<td>-0.446</td>
<td>11.674</td>
<td>15.701</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.899)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>0.925</td>
<td>0.463</td>
<td>0.215</td>
<td>0.016</td>
<td>0.144</td>
<td>6.290</td>
<td>1.262</td>
<td>1.435</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.341)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.004)</td>
<td>(NS)</td>
<td>(0.237)</td>
</tr>
<tr>
<td>3</td>
<td>POST-TEST 2 (for X1)</td>
<td>12.600</td>
<td>0.622</td>
<td>0.387</td>
<td>0.172</td>
<td>0.617</td>
<td>9.451</td>
<td>13.571</td>
<td>17.092</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(NS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>4</td>
<td>AGE</td>
<td>4.025</td>
<td>0.662</td>
<td>0.438</td>
<td>0.051</td>
<td>0.127</td>
<td>8.571</td>
<td>4.024</td>
<td>4.478</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.051)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.040)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D1</td>
<td>1.348</td>
<td>0.675</td>
<td>0.455</td>
<td>0.017</td>
<td>0.043</td>
<td>7.180</td>
<td>1.348</td>
<td>1.348</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.252)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(NS)</td>
<td>(0.252)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.392
### TABLE 9-8 (b)

**REGRESSION ANALYSIS FOR STAGE 1 SCIENCE (Xc)**

**DEPENDENT VARIABLE = FM**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D3</td>
<td>8.235 (0.006)</td>
<td>0.409</td>
<td>0.167</td>
<td>0.167</td>
<td>-0.409</td>
<td>8.235 (0.006)</td>
<td>12.433 (SS)</td>
<td>0.149 (0.701)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>0.763 (0.388)</td>
<td>0.428</td>
<td>0.189</td>
<td>0.016</td>
<td>0.099</td>
<td>4.47 (0.018)</td>
<td>1.191 (NS)</td>
<td>0.859 (0.360)</td>
</tr>
<tr>
<td>3</td>
<td>POST-TEST 2 (for Xc)</td>
<td>20.968 (0.001)</td>
<td>0.685</td>
<td>0.469</td>
<td>0.286</td>
<td>0.682</td>
<td>11.461 (0.001)</td>
<td>21.292 (SS)</td>
<td>23.503 (0.001)</td>
</tr>
<tr>
<td>4</td>
<td>AGE</td>
<td>2.376 (0.132)</td>
<td>0.707</td>
<td>0.500</td>
<td>0.031</td>
<td>0.084</td>
<td>9.493 (0.001)</td>
<td>2.308 (NS)</td>
<td>2.493 (0.123)</td>
</tr>
<tr>
<td>5</td>
<td>D2</td>
<td>0.224 (0.639)</td>
<td>0.709</td>
<td>0.503*</td>
<td>0.003</td>
<td>-0.068</td>
<td>7.484 (0.001)</td>
<td>0.224 (NS)</td>
<td>0.224 (0.639)</td>
</tr>
</tbody>
</table>

* adjusted R² = 0.436
9.5 Predictors of the Final Mark for Stage 1 Science Contd.

We conclude that overall the score on Post-test 2 is the best predictor of final mark with age also significant for X1 but much less so. Subjects who performed well on the Post-test also tended to perform well at the final course mark assessed by an exam and performance throughout the year. Intelligence and previous experience do not contribute additional predictive power. Even the simple correlation coefficient, r, between FM and intelligence is only about 0.10 to 0.15.

6 Item Analysis

We saw in Section 9.2.1. (a) that method has a statistically significant effect for the topic X1. In order to investigate the source of this effect in more detail, an item analysis was carried out on the 27 separate items comprising the Pre-test and Post-test 1. (Post-test 2 is not considered in this section).

The results are shown in Figure 9-4. One sees immediately that most subjects found Items 7,8,9,15,16,17,20,21,22 and 27 on the Pre-test quite difficult, indicating little pre-knowledge of the associated concepts e.g. the concepts of phasor diagram and phase angle. The question arises as to whether the significant method effects show up through these items or, through item for which there is a greater degree of pre-knowledge, or through both.

An analysis of covariance was therefore carried out on the part of the test comprising Items 7,8,9,15,16,17,20,21,22 and 27 and the part comprising the remaining items. With intelligence, FM and age as covariates and method and PE as factors it was found that method was not having a statistical significant effect for the former sub-test (F and significance of F and eta values being 0.192, 0.663 and 0.01 respectively) but was having a very significant effect for the latter sub-test (F and significance of F and eta values being 11.896, 0.001 and 0.37 respectively). This analysis included those subjects who did not sit for the Pre-test as the latter was not a covariate in this analysis.
9.6 Item Analysis Contd.

Thus the method effects are strongest for those items where the subjects experienced least difficulty in the Pre-test. However as we noted in Section 9.7.1. (a) no such distinction could be made for the topic Xc which most subjects found considerably easier than X1.

A consideration of the test structure reveals that items 5, 6 and 27 require some verbal manipulation being of the "Briefly explain" variety. All subjects, especially those in the lecture group, appear to improve only marginally on these items between the Pre-test and Post-test 1. Although the number of such "verbal items" are too small for a fuller analysis it appears that these subjects find some difficulty with verbal expression or explanation despite their generally above average intelligences. (Table 7-1).

9.7 Summary

Two experimental runs were carried out with Stage 1 Science students at Kilkenny College of Further Education, one run for each of two related topics, Inductive reactance ("X1") and capacitive reactance ("Xc"). The same basic population, numbering about 45 - 50, was used for each experiment. Random allocation was employed for X1 and then the groups interchanged for Xc. Only two teaching methods were investigated, didactic teaching and self-paced learning using microfiche.

(a) For X1 the microfiche-group performed significantly better than the lecture-group for Post-test 1. The amount of variance accounted for was only about 5% whether method effects are processed first or last in the analysis. This however was still significant as about 65% of the variance could be accounted for by the independent variables together. For Post-test 2 no method effects were significant.

(b) For Xc both groups performed nearly the same on both Post-test 1 and Post-test 2. Both "direct" and "total" method effects were virtually nil.
9.7 Summary Contd.

(c) The self-paced subjects took an average of about 50 minutes to work through the programmes for both topics, their individual times being determined by their previous experience, prior-knowledge, age and intelligence. Thus about half of the subjects spent longer on the programmes than the duration of the lecture period which was also of about 50 minutes duration.

(d) Analysis of covariance and multiple regression analysis when used to analyse Post-test 1 and Post-test 2 scores, and also to investigate times taken by self-paced subjects, produced similar results.

(e) An item analysis for XI showed that the method effects reported in (a) arose mainly from test items for which the subjects possessed some knowledge. The analysis also suggests that subjects experience difficulty with items requiring verbal manipulation of concepts.
10. DISCUSSION OF EMPIRICAL RESULTS III : THE WOODVILLE HIGH SCHOOL PROJECT

1 INTRODUCTION : Population Data

Thus far the empirical work carried out with post-secondary mathematics and science students at Kilkenny College of Further Education has been discussed, the relevant "population data" being enumerated in Table 7-1. As described in Section 7.4, it was decided to broaden the scope of the project by carrying out investigations at a large Adelaide suburban high school (Woodville High School or "W.H.S.") using first year secondary mathematics students.

Table 10-1 sets out the overall characteristics of the group. Column A refers to the 201 subjects who sat for all tests and for whom all information was available, while Column B refers to the entire 234 subjects involved in the investigations at some stage.

The experiment was conducted in September whereas the IQ, reading test and mathematical aptitude tests had been administered in February. Some details of the tests are supplied below.

(1) The IQ test was a general intelligence test which had been used in South Australian schools for many years on a routine basis before such (routine) testing was discontinued. The test was prepared by the Psychological Services Branch of the S.A. Education Department and is entitled "General Intelligence Test D". As with the ACER tests (Section 7.1.1) the raw scores are corrected to "IQ" by adjusting for chronological age.

(2) The reading test was a standard "Gapidol" test which also had been prepared by the Psychological Services Branch and had been widely used. The test is limited in that the maximum possible score is "12½ years" for the subject's reading age. As the average chronological age of the subjects is near the upper limit (Table 10-1(a)) the test serves mainly as an indication of which subjects have a reading age noticeably lower than their chronological age.

(3) The mathematical aptitude test is perhaps a misnomer and would be better described as a mathematical understanding test. The test was developed by the senior mathematics master at the school using the most recent version of the Primary School Mathematics syllabus.
### TABLE 10-1(a)

**POPULATION DATA** FOR W.H.S. SUBJECTS

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>A (N = 201)</th>
<th>B (N = 234)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>IQ</td>
<td>102.60</td>
<td>10.93</td>
</tr>
<tr>
<td></td>
<td>119.43</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>-1.01</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>1.88</td>
<td></td>
</tr>
<tr>
<td>RA</td>
<td>11.12</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>13.00</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>P-ONE</td>
<td>0.02</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>P-TV</td>
<td>-0.05</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>
10.1 Population Data Contd.

as a basis and selecting those skills and concepts which would be most necessary and/or useful in enabling the student (subject) to handle the Junior Secondary School Mathematics courses. The test contained 45 questions for which two marks each were allotted. It was administered to primary school students of "average ability" in various years thus enabling a "mathematical age" to be established for each score out of 90. Slight adjustments were made to bring the results into line with reading age and previously used standard mathematical tests for which similar norms were available.*

The average mathematical aptitude of all subjects was set originally at -0.5, but during the five years since the test was developed, the average score of the subjects has steadily decreased to the -1.0 (approximately) shown in Table 10-1(a).**

A score of say - 1.5 in this test would indicate that the subject is about 1½ years away from having attained a completely satisfactory working knowledge and understanding of all the straightforward mathematical ideas, skills and concepts tested.

Table 10-1 also includes two personality measures "P-One" and "P-Two". The precise method of calculating these and checking their reliability will be given in Appendix 2, but briefly three teachers were asked to independently rate each subject on two measures:

(a) P-One. Extroversion and Introversion (- 2 to + 2).
(b) P-Two. Interest and concentration (- 2 to + 2).

These "raw scores" were then converted to normal scores which were averaged over the three teachers to give the values for "P-One" and "P-Two" used in the analysis. The reliability of these "subjective" scales was found to be quite high (about 0.8) and although one would be rash to equate P-One and P-Two with extroversion or concentration scores obtained by more "objective" tests, they behaved as legitimate independent variables in the analysis, with P-Two accounting for a significant amount of variance in the dependent variables, over and above that explained by other independent variables, (see Tables 10-14 and 10-15 later).

* Details are obtainable from the mathematics master involved, Mr. John Riches, now Deputy-Head at Port Pirie High School, S.A.

** This decrease reflects the introduction of "promotion on age" policy in S.A. Primary Schools and not necessarily an actual decline in mathematical ability of students in the last year of primary school.

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10.2 Population Test Data

Only one topic was used in this investigation, "Percentages". The test data are shown in Table 10-1(b) for the 201 subjects who sat for all tests.

**TABLE 10-1(b)**

"POPULATION TEST DATA" FOR W.H.S. SUBJECTS

MARKS OUT OF 20 IN 30 MINUTES MAXIMUM

<table>
<thead>
<tr>
<th></th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
<th>t12</th>
<th>t23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.55</td>
<td>8.45</td>
<td>10.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>2.66</td>
<td>4.56</td>
<td>4.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>7.08</td>
<td>20.78</td>
<td>22.53</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(N = 201)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As noted in Section 7.4, Post-test 2 was not a "retention test" as the subjects received some instruction in the topic during the period between Post-tests 1 and 2. However, as expected, the gain between Post-tests 1 and 2 was less than that between the Pre-test and Post-test 1.

3 Sample Data

Although an attempt was made to allocate subjects to the experimental and control groups randomly, (alphabetically by surnames) it was subsequently found that the lecture-group did perform marginally worse than the other groups on most aptitude measures. However, the differences between groups were not significant at the 0.05 level for a two-tailed t test for independent samples. About 90 subjects were originally allocated to each of the three groups but the final effective group sizes were only in the range of 60 - 70 because not all subjects sat for all tests which required continued attendance over a period of 5 weeks (see Section 7.4). Thus all relevant variables were not fully under the control of the researchers, a situation which is, of course, quite common in social science research.

Table 10-2 enumerates the relevant statistical data for the three groups, namely didactic, self-paced using fiche and booklets. In this case t12 is the t value for the differences in means between the lecture and microfiche-groups using a two-tailed test and "NS" denotes not significant at the 0.05 level for that test. Table 10-2 is for the 201 subjects.
### TABLE 10-2
SAMPLE DATA FOR W.H.S. SUBJECTS

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>LECTURE-GROUP (1)</th>
<th>MICROFICHE-GROUP (2)</th>
<th>BOOKLET-GROUP (3)</th>
<th>t12</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRETEST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.97</td>
<td>4.81</td>
<td>4.88</td>
<td>1.83</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.73</td>
<td>2.53</td>
<td>2.61</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>7.46</td>
<td>6.64</td>
<td>6.82</td>
<td></td>
</tr>
<tr>
<td>(N = 68)</td>
<td></td>
<td>(N = 67)</td>
<td>(N = 66)</td>
<td></td>
</tr>
<tr>
<td>POST-TEST 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>7.59</td>
<td>9.05</td>
<td>8.77</td>
<td>1.82</td>
</tr>
<tr>
<td>S.D.</td>
<td>4.72</td>
<td>4.56</td>
<td>4.27</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>22.26</td>
<td>20.79</td>
<td>18.24</td>
<td></td>
</tr>
<tr>
<td>(N = 68)</td>
<td></td>
<td>(N = 67)</td>
<td>(N = 66)</td>
<td></td>
</tr>
<tr>
<td>POST-TEST 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>10.31</td>
<td>11.24</td>
<td>10.91</td>
<td>1.11</td>
</tr>
<tr>
<td>S.D.</td>
<td>5.13</td>
<td>4.60</td>
<td>4.33</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>26.27</td>
<td>21.15</td>
<td>18.74</td>
<td></td>
</tr>
<tr>
<td>(N = 68)</td>
<td></td>
<td>(N = 67)</td>
<td>(N = 66)</td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>100.73</td>
<td>104.47</td>
<td>102.64</td>
<td>1.86</td>
</tr>
<tr>
<td>S.D.</td>
<td>11.50</td>
<td>11.86</td>
<td>9.19</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>132.17</td>
<td>140.65</td>
<td>84.42</td>
<td></td>
</tr>
<tr>
<td>(N = 68)</td>
<td></td>
<td>(N = 67)</td>
<td>(N = 66)</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>-1.21</td>
<td>-0.92</td>
<td>-0.89</td>
<td>1.21</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.44</td>
<td>1.35</td>
<td>1.34</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
<td>2.08</td>
<td>1.81</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td>(N = 68)</td>
<td></td>
<td>(N = 67)</td>
<td>(N = 66)</td>
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<tr>
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<td></td>
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<tr>
<td>Mean</td>
<td>10.80</td>
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<td>11.35</td>
<td>1.93</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.32</td>
<td>1.21</td>
<td>1.08</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
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<td>1.45</td>
<td>1.17</td>
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<td>(N = 67)</td>
<td>(N = 66)</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td></td>
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<tr>
<td>Mean</td>
<td>12.96</td>
<td>12.96</td>
<td>13.05</td>
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<td>0.60</td>
<td>0.50</td>
<td>0.53</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
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<td>0.25</td>
<td>0.28</td>
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<td>(N = 67)</td>
<td>(N = 66)</td>
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</tbody>
</table>

CONT'D.
### TABLE 10-2 CONTD.

**SAMPLE DATA FOR W.H.S. SUBJECTS**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>LECTURE-GROUP</th>
<th>MICROFICHE-GROUP</th>
<th>BOOKLET-GROUP</th>
<th>t12</th>
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</thead>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
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<tr>
<td><strong>P-ONE</strong></td>
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<tr>
<td>Mean</td>
<td>-0.09</td>
<td>0.21</td>
<td>-0.01</td>
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<td>0.97</td>
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<td>0.78</td>
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<td>(N = 65)</td>
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</tr>
<tr>
<td><strong>P-TWO</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>-0.07</td>
<td>-0.05</td>
<td>-0.07</td>
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<tr>
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<td>0.88</td>
<td>0.85</td>
<td>(NS)</td>
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<tr>
<td>Variance</td>
<td>0.88</td>
<td>0.78</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 67)</td>
<td>(N = 64)</td>
<td>(N = 65)</td>
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<tr>
<td><strong>FM</strong></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>64.15</td>
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<td>67.57</td>
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<td>S.D.</td>
<td>22.12</td>
<td>18.30</td>
<td>18.26</td>
<td>(NS)</td>
</tr>
<tr>
<td>Variance</td>
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<td>334.81</td>
<td>333.50</td>
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<tr>
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<td>(N = 68)</td>
<td>(N = 65)</td>
<td>(N = 65)</td>
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</tr>
</tbody>
</table>

10.3 **Sample Data Contd.**

who sat for all tests although personality data is not available for five of these, nor the final mark for three.

From Table 10-2 we see that only for the case of P-One is the score for the lecture-group significantly different from that of the microfiche-group and, as we will see in our subsequent analysis, this variable has a nearly negligible effect upon achievement scores.

Intuitively one suspects from Table 10-2 that differences in performances between the groups on the two Post-tests are due to differences in group ability and not to differences in method of instruction.

It is informative to use Hay's formula to calculate the amount of variance in Post-test 1 due to the treatment administered plus the differences due to group effects. (Hay's assumes these are zero) (137).
10.3 Sample Data Contd.

The formula is:

\[ \text{est } w^2 = \frac{t^2 - 1}{t^2 + N1 + N2 - 1} \]

where the symbols are self-explanatory.

Substituting \( t = 1.82 \), \( N1 = 68 \), \( N2 = 67 \) into (10-1) gives

\[ \text{est } w^2 = \frac{(1.82)^2 - 1}{(1.82)^2 + 68 + 67 - 1} = 0.017 \]

Treatment plus group effects thus only account for about 2% of the variance in Post-test 1 scores. Once group effects are removed using analysis of covariance or multiple regression analysis, treatment effects, one suspects, would nearly disappear. This in fact is the case (see Table 10-13 (a) later).

.4 Graphical Representations: A

Figures 10-1 to 10-8 (d) present some graphical information relating to Pre-test, Post-test 1 and Post-test 2 scores to the other variables enumerated in Table 10-2 and to the sex of the subjects (which can be termed "attributive variables" for convenience).

In each case, except Figure 10-1 which simply presents the overall Pre-test and Post-test data directly from Table 10-2, the attributive variable is dichotomised at the mean for the population from which the data in Table 10-2 is drawn. The tables which follow list all relevant information for the sub-groups thus created.

Each figure includes separate representations for each group of subjects. Thus from the figures one can obtain some idea of the overall effect of each attributive variable over all teaching situations and of the effect of each attributive variable for each teaching situation.

The various figures are as follows:

(a) Figure 10-1 presents the overall test data for the three methods. The data are not tabulated as it is available directly from Table 10-2.

(b) Figures 10-2 (a) to 10-2 (d) show the effects of intelligence for each group. Table 10-3 lists the relevant data.
### TABLE 10-2

**INTELLIGENCE DATA**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SUB-GROUP</th>
<th>IQ</th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 LECTURE</td>
<td>Mean S.D.</td>
<td>109.97</td>
<td>5.42</td>
<td>10.34</td>
<td>13.81</td>
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<td></td>
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<td>2.29</td>
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<td>5.23</td>
<td>7.91</td>
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<tr>
<td></td>
<td>(N = 36)</td>
<td>8.17</td>
<td>2.42</td>
<td>3.94</td>
<td>4.03</td>
</tr>
<tr>
<td>2 MICROFICHE</td>
<td>Mean S.D.</td>
<td>113.34</td>
<td>5.96</td>
<td>11.29</td>
<td>13.33</td>
</tr>
<tr>
<td></td>
<td>(N = 36)</td>
<td>8.35</td>
<td>2.03</td>
<td>4.15</td>
<td>3.37</td>
</tr>
<tr>
<td></td>
<td>Mean S.D.</td>
<td>94.17</td>
<td>3.52</td>
<td>6.61</td>
<td>9.08</td>
</tr>
<tr>
<td></td>
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<td>5.36</td>
<td>2.64</td>
<td>3.73</td>
<td>4.72</td>
</tr>
<tr>
<td>3 BOOKLETS</td>
<td>Mean S.D.</td>
<td>109.97</td>
<td>5.56</td>
<td>11.05</td>
<td>13.38</td>
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<td>5.76</td>
<td>2.40</td>
<td>3.57</td>
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<td>4.09</td>
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<td>2.66</td>
<td>3.70</td>
<td>3.62</td>
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Fig 10-2(a)
Test Data for F1 The Group

>Mean IQ

<Mean IQ

SCORE

0 2 4 6 8 10 12 14

Pretest 1 Posttest 2 Posttest 2
<table>
<thead>
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<th>SUB-GROUP DATA</th>
<th>SUB-GROUP DATA</th>
</tr>
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<td>POST-TEST 1</td>
</tr>
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<td>5.73</td>
<td>10.64</td>
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<td>10.89</td>
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### TABLE 10-5
\textbf{READING AGE DATA}

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<tr>
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Fig. 10-44
Test Data for High Group.
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</thead>
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<td>PRETEST</td>
<td>POST-TEST 1</td>
<td>POST-TEST 2</td>
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<tr>
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<td>7.11</td>
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<td>4.00</td>
<td>7.84</td>
<td>10.55</td>
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<td></td>
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<td>Mean</td>
<td>13.29</td>
<td>4.40</td>
<td>8.30</td>
<td>10.32</td>
</tr>
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<td>2.92</td>
<td>4.92</td>
<td>4.98</td>
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<td>5.37</td>
<td>9.97</td>
<td>12.40</td>
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<td>5.08</td>
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<td>10.60</td>
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<td>2.44</td>
<td>4.37</td>
<td>4.45</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. X-5b
Test Data for Fische Group

SCORE

<Mean Age

>Mean Age

Protest
Posttest 1
Posttest 2
Pretest PosHest

Test Data for Socket Group

> Mean Age
< Mean Age

SCORE

Pretest | Posttest 1 | Posttest 2
Fig 10-5(a)
Total Test Data
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<tr>
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<td>S.D.</td>
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</tr>
<tr>
<td></td>
<td>(N = 29)</td>
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</tr>
<tr>
<td></td>
<td>Mean</td>
<td>-0.78</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>(N = 37)</td>
<td></td>
</tr>
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<td>2 MICROFICHE</td>
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</tr>
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<td>S.D.</td>
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</tr>
<tr>
<td></td>
<td>(N = 23)</td>
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</tr>
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<td>Mean</td>
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<td>S.D.</td>
<td>0.46</td>
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<td>(N = 37)</td>
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<tr>
<td></td>
<td>Mean</td>
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<td>S.D.</td>
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<td>(N = 29)</td>
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</tr>
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</table>
Fig. 10-6(b)
Test Data for Fiche Group

SCORE

>Mean P-One
<Mean P-One

Pretest          Posttest 1          Posttest 2
Fig. 10-6a)
Text Data for Booklet Group

![Chart showing pretest and posttest scores for two groups with a trend line indicating improvement over time.](chart.png)
Fig. 10-6(d)
Total Test Data

| Lecture | Fiche | Books | > Mean P-<One | < Mean, P-One |

SCORE

Pretest  | Posttest 1 | Posttest 2

0         | 2         | 4

10        | 12        | 14

Graph showing the comparison of different methods (Lecture, Fiche, Books) across pretest and posttest levels, with markers for > Mean P-<One and < Mean, P-One.
<table>
<thead>
<tr>
<th>GROUP</th>
<th>SUB-GROUP</th>
<th>i-TWO</th>
<th>PRETEST</th>
<th>POST-TEST 1</th>
<th>POST-TEST 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 LECTURE</td>
<td>Mean S.D. (N = 33)</td>
<td>0.69 0.60</td>
<td>2.70 2.30</td>
<td>5.03 4.13</td>
<td>6.74 3.61</td>
</tr>
<tr>
<td></td>
<td>Mean S.D. (N = 34)</td>
<td>-0.79 0.54</td>
<td>5.27 2.48</td>
<td>10.20 3.85</td>
<td>13.77 3.84</td>
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<tr>
<td>2 MICROFICHE</td>
<td>Mean S.D. (N = 30)</td>
<td>0.74 0.47</td>
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<td>7.45 3.93</td>
<td>9.77 4.61</td>
</tr>
<tr>
<td></td>
<td>Mean S.D. (N = 34)</td>
<td>-0.75 0.46</td>
<td>5.25 2.32</td>
<td>10.60 4.51</td>
<td>12.62 4.08</td>
</tr>
<tr>
<td>3 BOOKLETS</td>
<td>Mean S.D. (N = 31)</td>
<td>0.65 0.51</td>
<td>4.06 2.39</td>
<td>6.79 3.70</td>
<td>8.73 3.94</td>
</tr>
<tr>
<td></td>
<td>Mean S.D. (N = 35)</td>
<td>-0.70 0.51</td>
<td>5.60 2.61</td>
<td>10.53 4.00</td>
<td>12.84 3.73</td>
</tr>
<tr>
<td>GROUP</td>
<td>SUB-GROUP</td>
<td>SUB-GROUP DATA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRETEST</td>
<td>POST-TEST 1</td>
<td>POST-TEST 2</td>
<td></td>
</tr>
<tr>
<td>1 LECTURE</td>
<td>BOYS</td>
<td>4.46</td>
<td>7.89</td>
<td>10.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 37)</td>
<td>2.84</td>
<td>4.72</td>
<td>5.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GIRLS</td>
<td>3.50</td>
<td>7.23</td>
<td>10.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 31)</td>
<td>2.47</td>
<td>4.77</td>
<td>5.21</td>
<td></td>
</tr>
<tr>
<td>2 MICROFICHE</td>
<td>BOYS</td>
<td>4.79</td>
<td>8.57</td>
<td>10.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 36)</td>
<td>2.59</td>
<td>4.34</td>
<td>4.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GIRLS</td>
<td>4.84</td>
<td>9.56</td>
<td>11.71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 31)</td>
<td>2.60</td>
<td>4.82</td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td>3 BOOKLETS</td>
<td>BOYS</td>
<td>5.13</td>
<td>9.13</td>
<td>10.71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 40)</td>
<td>2.68</td>
<td>4.13</td>
<td>4.56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GIRLS</td>
<td>4.41</td>
<td>8.13</td>
<td>11.21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 26)</td>
<td>2.50</td>
<td>4.54</td>
<td>4.01</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 15-8(a)
Text: Data for Pocket Group

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest 1</th>
<th>Posttest 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Score
10.4 Graphical Representations : A Contd.

(c) Figures 10-3 (a) to 10-3 (d) show the effects of mathematical aptitude (MA) for each group. Table 10-4 lists the relevant data.

(d) Figures 10-4 (a) to 10-4 (d) show the effects of reading age (RA) for each group. Table 10-5 lists the relevant data.

(e) Figures 10-5 (a) to 10-5 (d) show the effects of chronological age for each group. Table 10-6 lists the relevant data.

(f) Figures 10-6 (a) to 10-6 (d) show the effects of P-One, the first personality measure, for each group. Table 10-7 lists the relevant data.

(g) Figures 10-7 (a) to 10-7 (d) show the effects of P-Two, the second personality measure, for each group. Table 10-8 lists the relevant data.

(h) Figures 10-8 (a) to 10-8 (d) show the effects of sex while Table 10-9 lists the relevant data.

As has been stressed previously (Section 8.2.3) considerable care is needed in interpreting graphical data such as that presented in Figures 10-1 to 10-8. They indicate only the 'total effect' of the attributive variables in each case and do not tell us whether such an effect is direct or is the effect of another highly correlated variable. Also the dichotomization procedure involves a considerable loss of data for non-categorical variables as all subjects are effectively grouped as either above or below the mean of the 'population' (remember we use this term to refer to the totality of subjects available).

It is helpful therefore to use a correlation matrix to assist in the interpreting of Figures 10-1 to 10-8. Table 10-10 supplies the relevant simple correlation coefficients between the attributive variables.

The high correlation between intelligence, MA, RA and to a lesser degree P-Two suggests that all would have a similar effect upon performance on the three tests, especially on Post-tests 1 and 2. The simple correlation between P-Two and intelligence, MA and RA is negative and so its effects, although similar to that of the others will be reversed, i.e. lower P-Two subjects will tend to perform better than higher P-Two subjects.
**TABLE 10-10**

CORRELATION MATRIX FOR VARIABLES IN FIGURES 10-1 TO 10-7

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>RA</th>
<th>AGE</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>D4**</th>
<th>D5**</th>
<th>INTELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>0.749*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RA</td>
<td>0.736*</td>
<td>0.620*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>0.227*</td>
<td>0.193*</td>
<td>0.011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-ONE</td>
<td>0.001</td>
<td>0.043</td>
<td>0.025</td>
<td>0.147</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-TWO</td>
<td>0.461*</td>
<td>0.492*</td>
<td>0.362*</td>
<td>0.135</td>
<td>0.308*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D4**</td>
<td>0.057</td>
<td>0.030</td>
<td>0.024</td>
<td>0.096</td>
<td>0.042</td>
<td>0.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5**</td>
<td>0.057</td>
<td>0.030</td>
<td>0.024</td>
<td>0.096</td>
<td>0.042</td>
<td>0.042</td>
<td>1.000*</td>
<td></td>
</tr>
</tbody>
</table>

* denotes significance at 0.05 level for two-tailed test

** dummy variables for sex with D4 = 1 for boys and D5 = 1 for girls, otherwise each is zero. D5 could, of course, have been omitted.
10.4 Graphical Representations : A Contd.

Although P-One has a moderately high correlation with P-Two, its correlation with all other tabulated variables is statistically insignificant. Thus if it is producing a significant effect it will probably indicate a "direct effect".

Similarly sex and age are generally poorly correlated with other variables and any significant effect from these would probably indicate "direct effects".

In fact, P-One, sex and age, as the Figures indicate, do not exert a very pronounced effect upon test scores. Later we will look at just what is their effect.

Method is also, of course, a pertinent variable but is "experimental" rather than "attributive" and so was not included in Table 10-10. It will be included in the full statistical analysis together with the others as independent variables but Figure 10-1 suggests its effect is small once allowance is made for Pre-test differences.

Probably intelligence, MA, RA and to a lesser degree, P-Two are measuring very similar subject attributes but it is beyond the province of this section to pursue this further by factor analytic methods.* This section will treat them as direct variables and leave it to the ANOVA and multiple regression analysis to sort out the effects of each one after the others have been adjusted for, or when entered in a hierarchical sequence.

.5 Graphical Representations : B

It is worthwhile pursuing the discussion in the last section a little further, before entering upon a more detailed analysis. We saw that the following ' attributive' variables are each producing significant total effects:

IQ
MA
RA
P-Two

---

* However, a brief factor analysis of the data is presented in Appendix 5.
10.5 **Graphical Representations**: B Contd.

whereas the following are not ("significant" here is not being used with reference to any strict statistical canons of course).

Sex, age

P-One

Now IQ, MA, RA and P-Two, especially the first three, are all highly correlated with one another and with the test scores. Tables 10-3, 10-4, 10-5, 10-8 and Figures 10-9 (a) to 10-9 (d) show the "total" effects of intelligence, MA, RA and P-Two respectively. In each figure the slopes of the three linear relationships, corresponding to the three methods, are very similar. We see that intelligence, MA and P-Two all exert about equally strong effects on the Post-test 1 scores but the effect of RA is rather less.

Because of the high correlation between these four variables it is possible that, although not identical, they are all, in large measure, reflections of the same cognitive attribute or set of attributes.

The Figures 10-9 (a) to 10-9 (d) indicate that a subject's performance on Post-test 2 is largely determined by his intelligence, MA, RA and P-Two scores rather than by the method of instruction. A full analysis is required to sort out these variables from one another and their "direct" from their "total" effects and this is given later in this Section.

The rectilinear relationships in each figure are of similar shape but, of course, are not coincident because of the small sub-group differences. The lecture-group, as we noted previously, usually falls slightly below the two self-paced groups on the major attributive variables. Such "group effects" account for most of the differences not explained by intelligence, MA, RA or P-Two and are taken up in the full analysis of covariance by using Pre-test as a principal covariate (see sub-section 10.6 and 10.9).

Figures 10-9 (e) and 10-9 (f) show the effects of sex and chronological age. Here however, the attributive variable is producing no overall consistent tendency and the differences, one suspects, are due to differ-
Fig. 10-9(a)
Effects of IQ and method on First Posttest scores
Fig. 10-95
Effects of M.A. and retention on first posttest score.
Fig. 10-9(c)
Effects of R.A. and method on First Posttest score.
Fig. 1C-3(a)
Effects of P-Two and method on First Posttest score.
Fig. 10-9(a)
Effects of sex and method on First Posttest scores.
10.5 **Graphical Representations : B Contd.**

ences in the sub-groups. To check this the sub-group scores were 'normalized' (roughly) by dividing by the respective sub-group Pre-test scores. The results, shown in Figures 10-9 (g) and 10-9 (h) show that the "adjusted" sex and age effects are nearly the same for each teaching method and practically nil in each case.

P-One does not seem to be exerting much effect and no overall trends are evident from Figure 10-9 (i). This will be verified by later analysis.

6 **Analysis of Covariance**

The above simple graphical representations are informative but only a thorough analysis can decide whether the various variables considered make a statistically significant contribution to the Post-test scores. Although the term "statistically significant" is considerably overworked, it is informative as long as one bears in mind other pertinent factors such as sample size (see Section 5.2.7). More informative is the amount of variance contributed by each independent variable (reverting back to the previous nomenclature) to the dependent variables either when processed first or last in the analysis or at some intermediate step which is known or pre-determined.

Tables 10-11 (a) to 10-12 (c) present the results of the SPSS /ANOVA sub-programme for various runs on the 201 subjects for whom all test data were available (full personality data available for 196). The runs were as follows:

(a) **For Post-test 1**

(1) Post-test 1 with sex and method with Pre-test, Intelligence, age, P-One and P-Two as covariates.

(2) Post-test 1 with sex and method with Pre-test, Intelligence and age as covariates.

(3) Post-test 1 with sex with Pre-test, Intelligence, age P-One and P-Two as covariates.

(4) Post-test 1 with sex with Pre-test, Intelligence and age as covariates.
Fig. 10-9(f)
Effects of age and method on first posttest scores.
Fig. 10-9(g)
Effects of sex and method on normalised Posttest scores.
Fig. 10-9(n)
Effects of age and method on normalised Posttest scores.
Fig. 10-9(c)
Effects of P-One and method on First Posttest scores.
10.6 Analysis of Covariance Contd.

(b) For Post-test 2

(1) Post-test 2 with sex and method with Post-test 1, intelligence, age, P-One and P-Two as covariates.

(2) Post-test 2 with sex and method with Post-test 1, intelligence and age as covariates.

(3) Post-test 2 with Post-test 1, intelligence, age, P-One and P-Two as covariates.

(4) Post-test 2 with sex with Post-test 1, intelligence and age as covariates.

A comparison of (1) and (2) will give an indication of the effect of the personality variables, P-One and P-Two, while a comparison of (1) and (3) (or (2) and (4)) will give an indication of the effect of method.

1 Analysis of Post-test 1

In each of the four runs shown in Table 10-11, the covariates Pre-test, Intelligence and P-Two are highly significant with significance of F values of 0.001 or less, while age and P-One are not significant, in agreement with our discussions in Sections 10.4 and 10.5.

From Table 10-11 (c) we see that removing P-One and P-Two from the analysis reduces the explained variance, $R^2$, from 0.555 to 0.521. Thus the personality variables account for about 3.4% of the overall variance most of this, of course, being due to P-Two.

Also from Table 10-11 (c) we see that method only accounts for about $0.555 - 0.552 = 0.003$ or less of the variance in the dependent variable. Although $\eta^2$ is about 0.026 (for run 1) even this small contribution fades away to nearly zero when adjustments are made for the other independent variables.

It must be remembered that each of the covariates Pre-test, Intelligence and P-Two are making a highly significant contribution to Post-test 1 scores after adjustments have been made for other covariates. Had mathematical aptitude been included as a covariate, the additional contribution due to intelligence would probably be greatly
TABLE 10-11 (a)
ANALYSIS OF POST-TEST 1 (WITH PRETEST AS A COVARIATE)

SIGNIFICANCE OF F VALUES

<table>
<thead>
<tr>
<th>RUN</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>SEX</th>
<th>METHOD</th>
<th>SEX X METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.001</td>
<td>0.001</td>
<td>0.597</td>
<td>0.474</td>
<td>0.001</td>
<td>0.315</td>
<td>0.566</td>
<td>0.422</td>
</tr>
<tr>
<td>(N = 196)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.001</td>
<td>0.001</td>
<td>0.701</td>
<td>-</td>
<td>-</td>
<td>0.860</td>
<td>0.884</td>
<td>0.546</td>
</tr>
<tr>
<td>(N = 201)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>0.001</td>
<td>0.596</td>
<td>0.473</td>
<td>0.001</td>
<td>0.331</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(N = 196)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.001</td>
<td>0.001</td>
<td>0.779</td>
<td>-</td>
<td>-</td>
<td>0.857</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(N = 201)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 10.11 (b)

**ANALYSIS OF POST-TEST 1 (WITH PRETEST AS A COVARIATE)**

**F VALUES**

<table>
<thead>
<tr>
<th>RUN</th>
<th>PRETEST</th>
<th>INTELL</th>
<th>AGE</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>SEX</th>
<th>METHOD</th>
<th>SEX X METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (N = 196)</td>
<td>47.547</td>
<td>19.552</td>
<td>0.281</td>
<td>0.514</td>
<td>16.269</td>
<td>1.016</td>
<td>0.536</td>
<td>0.867</td>
</tr>
<tr>
<td>2 (N = 201)</td>
<td>57.211</td>
<td>37.107</td>
<td>0.078</td>
<td>-</td>
<td>-</td>
<td>0.031</td>
<td>0.123</td>
<td>0.607</td>
</tr>
<tr>
<td>3 (N = 196)</td>
<td>47.849</td>
<td>19.677</td>
<td>0.283</td>
<td>0.517</td>
<td>16.374</td>
<td>0.948</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (N = 201)</td>
<td>57.963</td>
<td>37.594</td>
<td>0.079</td>
<td>-</td>
<td>-</td>
<td>0.033</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE 10-11 (c)

**ANALYSIS OF POST-TEST 1 (WITH PRETEST AS A COVARIATE)**

**VALUES OF ETA, BETA AND MULTIPLE R**

<table>
<thead>
<tr>
<th>RUN</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>METHOD**</td>
<td>0.16</td>
<td>0.05</td>
<td>0.745</td>
</tr>
<tr>
<td></td>
<td>SEX***</td>
<td>0.02</td>
<td>0.05</td>
<td>(0.555)</td>
</tr>
<tr>
<td></td>
<td>(N = 196)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>METHOD</td>
<td>0.14</td>
<td>0.03</td>
<td>0.722</td>
</tr>
<tr>
<td></td>
<td>SEX</td>
<td>0.01</td>
<td>0.01</td>
<td>(0.521)</td>
</tr>
<tr>
<td></td>
<td>(N = 201)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SEX</td>
<td>0.02</td>
<td>0.05</td>
<td>0.743</td>
</tr>
<tr>
<td></td>
<td>(N = 196)</td>
<td></td>
<td></td>
<td>(0.552)</td>
</tr>
<tr>
<td>4</td>
<td>SEX</td>
<td>0.01</td>
<td>0.01</td>
<td>0.721</td>
</tr>
<tr>
<td></td>
<td>(N = 201)</td>
<td></td>
<td></td>
<td>(0.520)</td>
</tr>
</tbody>
</table>

* squares of quantities are shown in brackets

** three methods

*** two categories
10.6.1 Analysis of Post-test 1 Contd.

reduced and intelligence might no longer be significant. When interpreting the results for any variable it is necessary to bear in mind the total array of variables and, if possible, the approximate inter-relationships between them.

As a factor, sex is exerting very little effect and there is no significant interaction between sex and method.

.2 Analysis of Post-test 2

The results here, see Tables 10-12 (a) to 10-12 (c), are nearly the same as for Post-test 1 except that more variance of Post-test 1 is accounted for, since Post-test 1 is a very strong covariate (F values of more than 100). Post-test 1, Intelligence and P-Two are all highly significant with significance of F values of 0.001 or less while age and P-One are not significant.

From Table 10-12 (c) we see that removing P-One and P-Two from the analysis reduces the explained variance from 0.68 to 0.668 i.e. they account for about 2.1% of the overall variance. Again most of this will be due to P-Two and, although small, becomes significant with N values of about 200.

We see also that method is accounting for about 0.689 - 0.689 = 0.000 of the variance and even eta2 is only 0.012. After adjusting for other independent variables, method effects nearly disappear altogether.

Once again, of course, sex is exerting very little effect and there is no significant interaction between sex and method.

.7 Multiple Regression Analysis

For the purposes of the multiple regression analysis a number of dummy variables were created in the usual manner.
### TABLE 10-12 (a)

**ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)**

**SIGNIFICANCE OF F VALUES**

<table>
<thead>
<tr>
<th>RUN</th>
<th>POST-TEST 1</th>
<th>INTELL</th>
<th>AGE</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>SEX</th>
<th>METHOD</th>
<th>SEX X METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (196)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.459</td>
<td>0.987</td>
<td>0.001</td>
<td>0.989</td>
<td>0.920</td>
<td>0.543</td>
</tr>
<tr>
<td>2 (201)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.587</td>
<td>-</td>
<td>-</td>
<td>0.488</td>
<td>0.690</td>
<td>0.320</td>
</tr>
<tr>
<td>3 (196)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.456</td>
<td>0.987</td>
<td>0.001</td>
<td>0.998</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (201)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.586</td>
<td>-</td>
<td>-</td>
<td>0.484</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
TABLE 10-12 (b)
ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)

<table>
<thead>
<tr>
<th>RUN</th>
<th>POST-TEST 1</th>
<th>INTELL</th>
<th>AGE</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>SEX</th>
<th>METHOD</th>
<th>SEX X METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (N = 196)</td>
<td>101.269</td>
<td>19.097</td>
<td>0.550</td>
<td>0.000</td>
<td>12.943</td>
<td>0.000</td>
<td>0.083</td>
<td>0.613</td>
</tr>
<tr>
<td>2 (N = 201)</td>
<td>138.935</td>
<td>27.209</td>
<td>0.296</td>
<td>-</td>
<td>-</td>
<td>0.483</td>
<td>0.371</td>
<td>1.145</td>
</tr>
<tr>
<td>3 (N = 196)</td>
<td>102.686</td>
<td>19.364</td>
<td>0.558</td>
<td>0.000</td>
<td>13.124</td>
<td>0.998</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (N = 201)</td>
<td>139.624</td>
<td>27.344</td>
<td>0.297</td>
<td>-</td>
<td>-</td>
<td>0.484</td>
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</tbody>
</table>
### TABLE 10-12 (c)

ANALYSIS OF POST-TEST 2 (WITH POST-TEST 1 AS A COVARIATE)

VALUES OF ETA, BETA AND MULTIPLE R*

<table>
<thead>
<tr>
<th>RUN</th>
<th>FACTOR</th>
<th>ETA</th>
<th>BETA</th>
<th>MULTIPLE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>METHOD</td>
<td>0.11</td>
<td>0.02</td>
<td>0.830</td>
</tr>
<tr>
<td></td>
<td>SEX</td>
<td>0.04</td>
<td>0.00</td>
<td>(0.689)</td>
</tr>
<tr>
<td>2</td>
<td>METHOD</td>
<td>0.09</td>
<td>0.04</td>
<td>0.817</td>
</tr>
<tr>
<td></td>
<td>SEX</td>
<td>0.04</td>
<td>0.03</td>
<td>(0.668)</td>
</tr>
<tr>
<td>3</td>
<td>SEX</td>
<td>0.04</td>
<td>0.00</td>
<td>0.830</td>
</tr>
<tr>
<td>4</td>
<td>SEX</td>
<td>0.04</td>
<td>0.03</td>
<td>0.817</td>
</tr>
</tbody>
</table>

---

* squares of quantities are shown in brackets
** three methods
*** two categories
10.7 Multiple Regression Analysis Contd.

The control statements were as follows:

IF (METHOD EQ 1) D1 = 1 (lecture)
IF (METHOD EQ 2) D2 = 1 (microfiche)
IF (METHOD EQ 3) D3 = 1 (booklets)
IF (SEX EQ 1) D4 = 1 (boys)
IF (SEX EQ 2) D5 = 1 (girls)
IF (CLASS EQ 1) D6 = 1 (class one)
IF (CLASS EQ 2) D7 = 1 (class two)
IF (CLASS EQ 3) D8 = 1 etc.
IF (CLASS EQ 4) D9 = 1 "
IF (CLASS EQ 5) D10 = 1 "
IF (CLASS EQ 6) D11 = 1 "
IF (CLASS EQ 7) D12 = 1 "
IF (CLASS EQ 8) D13 = 1 "

The correlation matrix between the various variables, excluding the class variables D6 to D13, is shown in Table 10-13, which is an expanded version of Table 10-10.

We see that performances on Pre-test, Post-test 1 and Post-test 2 are all heavily correlated with one another and also with intelligence, mathematical aptitude, reading age and P-Two (negatively with the latter variable).

Method is poorly correlated with all other variables except that r reaches -0.141 between D1 and Post-test 1. Although r itself is not significant for degrees of freedom of about 200, we will see that D1 still contributes a significant amount of total variance to Post-test 1 in the regression analysis. However, this fades out when adjustments are made for other variables (see Tables 10-13(a) and 10-13(b)).

Final mark FM is heavily correlated with all test scores and also with intelligence, MA, RA and P-Two. Later it will be seen that one can predict FM rather well from these and other data (Table 10-17) accounting for about 70% of the variance in FM.

The dummies D1, D2, D3 are all heavily correlated amongst themselves as
### TABLE 10-13

**CORRELATION MATRIX FOR W.H.S. DATA (excluding data for classes)**

<table>
<thead>
<tr>
<th></th>
<th>POST-TEST 2</th>
<th>INTELL</th>
<th>AGE</th>
<th>MA</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>POST-TEST 1</th>
<th>RA</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>FM</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-TEST 2</td>
<td>0.645&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>INTELL</td>
<td>0.544&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.653&lt;sup&gt;a&lt;/sup&gt;</td>
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</tr>
<tr>
<td>AGE</td>
<td>-0.059&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.222&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>MA</td>
<td>0.657&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.755&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.749&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.193&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>D1</td>
<td>-0.156&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.087&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.124&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.020&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.100&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>D2</td>
<td>0.070&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.068&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.120&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.044&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.054&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.506&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>D3</td>
<td>0.087&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.019&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.006&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.064&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.046&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.500&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.494&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>D4</td>
<td>0.090&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.035&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.057&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.096&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.030&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.012&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.043&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.043&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>D5</td>
<td>0.090&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.035&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.057&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.096&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.030&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.012&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.043&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>0.092&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
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</tr>
<tr>
<td>POST-TEST 1</td>
<td>0.651&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.787&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.613&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.097&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.696&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.141&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.092&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.051&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.152&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>RA</td>
<td>0.421&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.486&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.736&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.011&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.620&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.183&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.051&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.152&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.494&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>P-ONE</td>
<td>0.084&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.087&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.147&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.043&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.123&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.152&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.494&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.004&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>P-TWO</td>
<td>0.380&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.576&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.461&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.135&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.494&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.009&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>FM</td>
<td>0.512&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.725&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.621&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.225&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.732&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.073&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.061&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.061&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.004&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>PRETEST</td>
<td>POST-TEST 2</td>
<td>INTELL</td>
<td>AGE</td>
<td>MA</td>
<td>D1</td>
<td>D2</td>
<td></td>
<td></td>
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</tbody>
</table>

<sup>a</sup> denotes significance at 0.05 level for two-tailed test.
### Table 10-13 (Contd.)

<table>
<thead>
<tr>
<th>POST-TEST 2</th>
<th>INTELL</th>
<th>AGE</th>
<th>MA</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>POST-TEST 1</th>
<th>RA</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>FM</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>POST-TEST 1</th>
<th>RA</th>
<th>P-ONE</th>
<th>P-TWO</th>
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</table>

* denotes significance at 0.05 level for a two-tailed test.
10.7 Multiple Regression Analysis Contd.

a subject who is not allocated to one group has about a 50% chance of being allocated to one of the remaining two groups. The correlation between D4 and D5 is, of course, just - 1.00 as each subject must be either one sex or the other.

There is a significant but small correlation between age and intelligence and MA. Younger subjects also tend to perform slightly better on the final mark, probably through the intelligence factor, but there is no significant correlation between age and performance on the Pre-test, Post-test 1 and Post-test 2. The correlation between sex and the other variables is nowhere significant and is less than 0.10 in all cases.

The correlation between method and other variables is, generally small but the lecture-group, indicated by D1, scores somewhat below the other groups on RA, Intelligence, Pre-test and Post-test 1 scores as we noted in Table 10-2. Only for RA is the correlation between D1 and the associated variable approaching significance, however with $r = -0.183$ (From Table 10-2, $t_{12}$ for RA was 1.95, a nearly significant value at the 0.05 level for a two-tailed t-test). Nevertheless later it will be seen (Tables 10-14 and 10-15) that RA fades out as a significant source of variance in Post-tests 1 and 2 after adjustments are made for Pre-test, Intelligence and MA.

1.1 Analysis of Post-test 1

1. Preliminary Investigations

To investigate the direct and indirect effects of the method variables on the Post-test 1 scores, two sequences of independent variables were used.

1. Pre-test
2. Intelligence
3. P-One
4. P-Two
5. D1, D2, D3 (method variables)

1. D1, D2, D3 (method variables)
2. P-Two
3. P-One
4. Pre-test
5. Intelligence

* For mathematics at the end of the year.
10.7.1.1 Preliminary Investigations Contd.

These sequences also give information about the effects of the personality factors as the subsequent discussion will indicate.

For the two runs shown in Table 10-13 (a) and Table 10-13 (b) the full 201 subjects who completed the Pre-test and Post-tests 1 and 2 were used. Full personality data was not available for 5, or about 2.5%, of these, and so this will slightly reduce the effective contributions due to P-One and P-Two for reasons described previously (see section 9.4 for a discussion of "missing data").

We see that when processed last the method variables account for only 0.2% of the variance in the dependent variable between them. When processed first they account for about 2% of the variance between them.*

This method contribution is significant at the 0.05 level for N of about 200 but this is probably due to the lecture-group being slightly below the other groups in intelligence and MA (see Table 10-2).

Thus direct effects of method are negligible and even the total effects of method are only accounting for about $0.020 \times 100 = 3.5\%$ of the explained variance.

The value of 0.020 for $\Delta R^2 = R^2 - r^2$ in Table 10-13 (b) is in good agreement with the value of $\eta^2 = 0.026$ obtained for run 1 in Table 10-11 (c), although the latter was for a slightly different population (i.e. one with missing data subjects automatically eliminated).

The Tables also indicate that although P-One is exercising no effect after adjustments are made for Pre-test and intelligence, it is significant if processed before the latter covariates but after P-Two. Because of the large number of subjects, "significant" here still means that only about 1.4% of the variance is

* This agrees with the result obtained from Hay's formula (10-1).
See sub-section 10.3.
### TABLE 10-13 (a)

**REGRESSION ANALYSIS FOR W.H.S. DATA**

**DEPENDENT VARIABLE = POST-TEST 1 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
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<td>PRETEST</td>
<td>146.752</td>
<td>0.651</td>
<td>0.424</td>
<td>0.424</td>
<td>0.424</td>
<td>146.752</td>
<td>186.522</td>
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<td></td>
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<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>39.275</td>
<td>0.721</td>
<td>0.520</td>
<td>0.095</td>
<td>0.613</td>
<td>107.126</td>
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<td>19.771</td>
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<tr>
<td></td>
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<td>(0.001)</td>
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<td></td>
<td>(SS)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>3</td>
<td>P-ONE</td>
<td>0.301</td>
<td>0.721</td>
<td>0.520</td>
<td>0.001</td>
<td>0.065</td>
<td>71.266</td>
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<td>(NS)</td>
<td>(0.334)</td>
<td>(0.334)</td>
</tr>
<tr>
<td>4</td>
<td>P-TWO</td>
<td>15.838</td>
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<td>0.505</td>
<td>61.434</td>
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<td></td>
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<td>(0.001)</td>
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<td>(SS)</td>
<td>(0.001)</td>
<td>(0.001)</td>
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<td>40.924</td>
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<td>(NS)</td>
<td>(0.518)</td>
<td>(0.518)</td>
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<td>0.999</td>
<td>0.747</td>
<td>0.559</td>
<td>0.002</td>
<td>0.092</td>
<td>(0.001)</td>
<td>0.999</td>
<td>(0.319)</td>
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</tbody>
</table>

* adjusted $R^2 = 0.545$
TABLE 10-13 (b)

REGRESSION ANALYSIS FOR W.H.S. DATA

DEPENDENT VARIABLE: POST-TEST 1 SCORE

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D1</td>
<td>3.624</td>
<td>0.141</td>
<td>0.020</td>
<td>0.020</td>
<td>-0.141</td>
<td>2.056</td>
<td>4.399</td>
<td>0.999</td>
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<td></td>
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<td>(0.058)</td>
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<td></td>
<td></td>
<td>(0.131)</td>
<td></td>
<td>(S)</td>
<td>(0.319)</td>
</tr>
<tr>
<td></td>
<td>D3</td>
<td>0.120</td>
<td>0.143</td>
<td>0.020</td>
<td>0.000</td>
<td>0.049</td>
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<td>0.136</td>
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<tr>
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<td>(0.730)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>(S)</td>
<td>(0.713)</td>
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<tr>
<td>2</td>
<td>P-TWO</td>
<td>68.957</td>
<td>0.524</td>
<td>0.274</td>
<td>0.254</td>
<td>-0.505</td>
<td>24.827</td>
<td>111.737</td>
<td>16.574</td>
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<td></td>
<td>(0.001)</td>
<td></td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>3</td>
<td>P-ONE</td>
<td>3.744</td>
<td>0.537</td>
<td>0.288</td>
<td>0.014</td>
<td>0.065</td>
<td>19.816</td>
<td>6.159</td>
<td>0.938</td>
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<td></td>
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<td></td>
<td>(0.001)</td>
<td></td>
<td>(S)</td>
<td>(0.334)</td>
</tr>
<tr>
<td>4</td>
<td>PRETEST</td>
<td>90.494</td>
<td>0.717</td>
<td>0.514</td>
<td>0.226</td>
<td>0.651</td>
<td>41.190</td>
<td>99.420</td>
<td>49.326</td>
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<td>(0.001)</td>
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<td>(0.001)</td>
<td></td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>5</td>
<td>INTELL</td>
<td>19.771</td>
<td>0.747</td>
<td>0.559</td>
<td>0.045</td>
<td>0.613</td>
<td>40.924</td>
<td>19.771</td>
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<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
</tbody>
</table>

*: adjusted R² = 0.545
10.7.1.1 Preliminary Investigations Contd.
accounted for (Table 10-13 (b)) but it is interesting that the
analysis brings out the effects of both personality factors
under certain conditions.

When processed after Pre-test and intelligence, P-Two accounts
for 3.6% of the variance but when processed before Pre-test and
intelligence it accounts for about 25.4% of the variance. This
is indicative of the relatively high simple correlation between
P-Two and the other two covariates (actually about 0.4 to 0.5).

Further information can be obtained by dropping out intelligence
altogether from the first sequence to give the results listed in
Table 10-13 (c).

Comparing Table 10-13 (c) with 10-13 (a) and 10-13 (b), we see
that intelligence accounts for 4.5% of the variance in Post-test
1 over and above that accounted for by the other independent
variables used in the analysis. However we also see that F3 for
P-One is no longer significant and, indeed, ΔR² = 0.000 when
P-One is entered on the second step immediately after Pre-test.
P-One thus acts indirectly via the Pre-test in this analysis.

Direct method effects are still negligible with intelligence
omitted but the contribution of P-Two has increased (from 3.6%
to 8.3%) as one might expect, i.e. P-Two is a better predictor
of Post-test 1 score but is still a much poorer predictor than
Pre-test.*

.2 Full Analysis
"Full analysis" means using as much of the available information
as possible.

* In Tables 10-13 (a) to 10-13 (c) F3 for the method variables were calculated
using the formula:

\[ F = \frac{(\text{FOR METHOD DUMMY VARIABLES})/2}{(1 - R^2)/(N - k - 1)} \]

For details of finding F for a subset of variables see the SPSS manual (138).
**TABLE 10-13 (c)**

**REGRESSION ANALYSIS FOR W.H.S. DATA**

**DEPENDENT VARIABLE = POST-TEST 1 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRETEST</td>
<td>146.752</td>
<td>0.651</td>
<td>0.424</td>
<td>0.424</td>
<td>0.651</td>
<td>146.752</td>
<td>170.123</td>
<td>90.494</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>2</td>
<td>P-ONE</td>
<td>0.038</td>
<td>0.652</td>
<td>0.425</td>
<td>0.000</td>
<td>0.065</td>
<td>73.040</td>
<td>0.000</td>
<td>3.142</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.846)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.846)</td>
<td>(0.078)</td>
</tr>
<tr>
<td>3</td>
<td>P-TWO</td>
<td>33.205</td>
<td>0.712</td>
<td>0.508</td>
<td>0.083</td>
<td>-0.505</td>
<td>67.681</td>
<td>33.302</td>
<td>34.764</td>
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<tr>
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<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>4</td>
<td>D3</td>
<td>0.528</td>
<td>0.712</td>
<td>0.508</td>
<td>0.000</td>
<td>0.049</td>
<td>41.190</td>
<td>1.204</td>
<td>0.528</td>
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<td>(0.469)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(NS)</td>
<td>(0.469)</td>
</tr>
<tr>
<td>4</td>
<td>D2</td>
<td>2.440</td>
<td>0.717</td>
<td>0.514*</td>
<td>0.006</td>
<td>0.092</td>
<td>2.440</td>
<td>2.440</td>
<td>2.440</td>
</tr>
<tr>
<td></td>
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<td>(0.120)</td>
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<td>(0.120)</td>
<td>(0.120)</td>
<td>(0.120)</td>
</tr>
</tbody>
</table>

* adjusted $R^2 = 0.501$
10.7.1.2 Full Analysis Contd.

One suspects that method effects would continue to remain small even after several additional variables such as mathematical aptitude (MA), reading age (RA) and class are controlled. However, this cannot be assumed and it is worthwhile to try and account for as much variance as possible in order to increase the overall sensitivity of the experiment. As pointed out in Section 5, an effect which requires too elaborate procedures to show up is probably mainly of academic interest but the full analysis is included for completeness and in order to better clarify the relationships between the various independent variables as well as between them and the dependent variable.

Table 10-14 shows the "full analysis" where the various dummy variables are those defined at the beginning of this Section.

Again method effects are nearly negligible accounting for only 0.2% of the variance in Post-test 1. Even with the fuller repertoire of independent variables available the amount of variance accounted for has increased only from about 56% to 61% in going from Table 10-13 (a) to Table 10-14, and there has been no enhancement of method effects.

Pre-test, MA and D10 are significant both at the step where they are entered in Table 10-14 and if they are processed last (statistics F3 and F4 respectively). Intelligence is significant if entered at step two but not if processed last, while RA is significant when entered both on step four, after Pre-test, intelligence and MA, and when entered last.

It is interesting to see that D10 is significant at the 0.05 level. This class thus performed significantly better than the other seven. Ten members of this class had received a conventional lesson or lecture, ten used microfiche and ten used booklets. Its mean IQ of 104.02 was slightly above the mean (102.60) for the entire population.*

* The school had tried to ensure that all 8 classes were of equal ability by using the intelligence, reading and mathematical aptitude tests (see Section 10.1) to unstream the pupils. The class under consideration was larger than most others. Possibly the arrival and departure of pupils during the year accounted for differences in performances between classes.
### Table 10.14

Regression Analysis for W.H.S. Data

**Dependent Variable: POST-TEST 1 Score**

<table>
<thead>
<tr>
<th>Step</th>
<th>Independent Variable</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRETEST</td>
<td>146.752</td>
<td>0.651</td>
<td>0.424</td>
<td>0.424</td>
<td>0.651</td>
<td>146.752</td>
<td>198.445</td>
<td>18.128</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>39.275</td>
<td>0.721</td>
<td>0.520</td>
<td>0.095</td>
<td>0.613</td>
<td>107.126</td>
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<td>3</td>
<td>MA</td>
<td>19.887</td>
<td>0.751</td>
<td>0.564</td>
<td>0.044</td>
<td>0.696</td>
<td>84.859</td>
<td>20.593</td>
<td>14.875</td>
</tr>
<tr>
<td>4</td>
<td>RA</td>
<td>0.073</td>
<td>0.751</td>
<td>0.564</td>
<td>0.000</td>
<td>0.474</td>
<td>63.363</td>
<td>0.000</td>
<td>0.077</td>
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<tr>
<td>5</td>
<td>AGE</td>
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<td>0.752</td>
<td>0.565</td>
<td>0.001</td>
<td>-0.097</td>
<td>50.683</td>
<td>0.468</td>
<td>0.179</td>
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<tr>
<td>6</td>
<td>P-ONE</td>
<td>0.389</td>
<td>0.752</td>
<td>0.566</td>
<td>0.001</td>
<td>0.065</td>
<td>42.168</td>
<td>0.468</td>
<td>0.712</td>
</tr>
<tr>
<td>7</td>
<td>P-TWO</td>
<td>10.486</td>
<td>0.767</td>
<td>0.588</td>
<td>0.022</td>
<td>-0.505</td>
<td>39.410</td>
<td>10.300</td>
<td>13.188</td>
</tr>
<tr>
<td>8</td>
<td>D4</td>
<td>0.586</td>
<td>0.768</td>
<td>0.590</td>
<td>0.001</td>
<td>0.012</td>
<td>34.483</td>
<td>0.468</td>
<td>0.579</td>
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<td>9</td>
<td>D13</td>
<td>1.185</td>
<td>0.768</td>
<td>0.590</td>
<td>0.000</td>
<td>0.011</td>
<td>18.978</td>
<td>0.000</td>
<td>1.169</td>
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<tr>
<td></td>
<td>D11</td>
<td>0.739</td>
<td>0.768</td>
<td>0.590</td>
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<td>-0.017</td>
<td>0.000</td>
<td>0.679</td>
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<tr>
<td></td>
<td>D7</td>
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<td>0.594</td>
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<tr>
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<td>D9</td>
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<td>0.030</td>
<td>0.000</td>
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<td>D8</td>
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<td>-0.040</td>
<td>1.404</td>
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<td>D12</td>
<td>0.276</td>
<td>0.773</td>
<td>0.597</td>
<td>0.001</td>
<td>0.102</td>
<td>0.468</td>
<td>0.279</td>
<td>0.598</td>
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</tr>
<tr>
<td></td>
<td>D10</td>
<td>4.363</td>
<td>0.779</td>
<td>0.606</td>
<td>0.009</td>
<td>0.063</td>
<td>4.212</td>
<td>4.250</td>
<td>0.041</td>
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<td>10</td>
<td>D3</td>
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<td>0.606</td>
<td>0.000</td>
<td>0.049</td>
<td>16.738</td>
<td>0.000</td>
<td>0.430</td>
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</tr>
<tr>
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<td>D2</td>
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<td>0.002</td>
<td>0.092</td>
<td>1.140</td>
<td>1.140</td>
<td>1.140</td>
</tr>
</tbody>
</table>

* Adjusted R² = 0.572
### TABLE 10-15

**REGRESSION ANALYSIS FOR W.H.S. DATA**

**DEPENDENT VARIABLE = POST-TEST 2 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POST-TEST 1</td>
<td>323.259</td>
<td>0.787</td>
<td>0.619</td>
<td>0.619</td>
<td>0.787</td>
<td>323.259</td>
<td>391.160</td>
<td>106.655</td>
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<td>(0.001)</td>
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<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(SS)</td>
<td>(SS)</td>
</tr>
<tr>
<td>2</td>
<td>INTELL</td>
<td>27.556</td>
<td>0.816</td>
<td>0.666</td>
<td>0.047</td>
<td>0.653</td>
<td>196.976</td>
<td>29.700</td>
<td>18.523</td>
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<td></td>
<td></td>
<td>(SS)</td>
<td>(SS)</td>
<td>(SS)</td>
</tr>
<tr>
<td>3</td>
<td>P-ONE</td>
<td>1.282</td>
<td>0.817</td>
<td>0.668</td>
<td>0.002</td>
<td>0.087</td>
<td>131.931</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.001)</td>
<td>(0.886)</td>
</tr>
<tr>
<td>4</td>
<td>P-TWO</td>
<td>15.753</td>
<td>0.832</td>
<td>0.692</td>
<td>0.025</td>
<td>-0.576</td>
<td>110.297</td>
<td>15.798</td>
<td>14.760</td>
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<td></td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(SS)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>5</td>
<td>D3</td>
<td>0.209</td>
<td>0.832</td>
<td>0.692</td>
<td>0.000</td>
<td>0.019</td>
<td>72.911</td>
<td>0.000</td>
<td>0.209</td>
</tr>
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<td></td>
<td></td>
<td>(0.648)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SS)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>0.147</td>
<td>0.832</td>
<td>0.693*</td>
<td>0.005</td>
<td>0.068</td>
<td>0.147</td>
<td>0.000</td>
<td>0.000</td>
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<td>(0.702)</td>
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<td></td>
<td></td>
<td>(NS)</td>
<td>(NS)</td>
<td>(0.001)</td>
</tr>
</tbody>
</table>

* adjusted $R^2 = 0.683$
10.7.2 **Analysis of Post-test 2**

Table 10-15 shows the result of a regression analysis carried out on Post-test 2 using a short list of independent variables similar to that used for Table 10-13 (a).

Method effects have faded out altogether (i.e. account for less than 0.05% of the variance) when processed last. The independent variables play nearly the same role as in Table 10-13 (a) except that Post-test 1, which is now the major covariate, accounts for by far the greatest percentage of explained variance.

\[
\left( \frac{0.619 \times 100}{0.693} \right) = 89.3\%
\]

and apparently has taken up some of the effects of intelligence and P-Two as well as method effects.

Again P-Two remains significant even when entered after intelligence, although it only accounts for an additional 2.5% of the variance in the dependent variable.

Table 10-16 presents the "full analysis" for Post-test 2 with all independent variables included in the analysis.

The additional variables have accounted for an additional \((74.8 - 69.3)\% = 5.5\%\) of the variance in the dependent variable, a result very similar to that obtained for Post-test 1 (Tables 10-13 (a) and 10-14).

Once again method has faded out and is making no contribution to the observed variance.

Tables 10-14 and 10-16 are remarkably similar as far as the significances of the variables are concerned. The main differences are with intelligence and D9. Even after adjustments are made for all other independent variables, intelligence now exerts a significant effect, unlike the case with Post-test 1. Over the intervening period intelligence thus apparently exercises an influence over and above that exercised by MA and P-Two.

The D9 class did significantly worse than the other classes on Post-test 2, although not on Post-test 1. The class seemed reasonably average in intelligence and other measures and there is no obvious reason for this drop in performance.
### TABLE 10-16

**REGRESSION ANALYSIS FOR W.H.S. DATA**

**DEPENDENT VARIABLE = POST-TEST 2 SCORE**

<table>
<thead>
<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R²</th>
<th>ΔR²</th>
<th>r</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POST-TEST 1</td>
<td>323.259</td>
<td>0.787</td>
<td>0.619</td>
<td>0.169</td>
<td>0.787</td>
<td>323.259</td>
<td>449.512</td>
<td>64.782</td>
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<tr>
<td>2</td>
<td>INTELL</td>
<td>27.556</td>
<td>0.816</td>
<td>0.666</td>
<td>0.047</td>
<td>0.653</td>
<td>196.976</td>
<td>34.131</td>
<td>4.721</td>
</tr>
<tr>
<td>3</td>
<td>MA</td>
<td>27.416</td>
<td>0.840</td>
<td>0.706</td>
<td>0.041</td>
<td>0.755</td>
<td>157.976</td>
<td>29.774</td>
<td>25.886</td>
</tr>
<tr>
<td>4</td>
<td>RA</td>
<td>1.274</td>
<td>0.842</td>
<td>0.708</td>
<td>0.002</td>
<td>0.486</td>
<td>118.965</td>
<td>1.452</td>
<td>2.945</td>
</tr>
<tr>
<td>5</td>
<td>AGE</td>
<td>1.591</td>
<td>0.843</td>
<td>0.711</td>
<td>0.002</td>
<td>0.100</td>
<td>95.777</td>
<td>1.452</td>
<td>1.715</td>
</tr>
<tr>
<td>6</td>
<td>P-ONE</td>
<td>1.735</td>
<td>0.845</td>
<td>0.713</td>
<td>0.003</td>
<td>0.087</td>
<td>80.404</td>
<td>2.179</td>
<td>0.005</td>
</tr>
<tr>
<td>7</td>
<td>P-TWO</td>
<td>12.692</td>
<td>0.855</td>
<td>0.731</td>
<td>0.018</td>
<td>0.576</td>
<td>74.856</td>
<td>13.071</td>
<td>10.149</td>
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<td>8</td>
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<td>0.035</td>
<td>65.190</td>
<td>0.000</td>
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<td>2.859</td>
<td>0.855</td>
<td>0.731</td>
<td>0.001</td>
<td>0.040</td>
<td>36.632</td>
<td>0.726</td>
<td>2.854</td>
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<td></td>
<td>D13</td>
<td>2.708</td>
<td>0.856</td>
<td>0.732</td>
<td>0.001</td>
<td>0.007</td>
<td>0.726</td>
<td>2.737</td>
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<tr>
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<td>D9</td>
<td>6.499</td>
<td>0.859</td>
<td>0.738</td>
<td>0.006</td>
<td>0.045</td>
<td>4.357</td>
<td>6.348</td>
<td>0.013</td>
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<tr>
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<td>D7</td>
<td>0.924</td>
<td>0.859</td>
<td>0.738</td>
<td>0.000</td>
<td>0.076</td>
<td>0.000</td>
<td>0.943</td>
<td>0.333</td>
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<td></td>
<td>D12</td>
<td>1.111</td>
<td>0.859</td>
<td>0.738</td>
<td>0.000</td>
<td>0.122</td>
<td>0.000</td>
<td>1.110</td>
<td>0.293</td>
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<td>D8</td>
<td>0.005</td>
<td>0.860</td>
<td>0.740</td>
<td>0.002</td>
<td>0.005</td>
<td>1.452</td>
<td>0.003</td>
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<td>D10</td>
<td>5.933</td>
<td>0.869</td>
<td>0.748</td>
<td>0.003</td>
<td>0.026</td>
<td>5.310</td>
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<td>0.019</td>
<td>32.015</td>
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<td>0.179</td>
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<td>D2</td>
<td>0.033</td>
<td>0.865</td>
<td>0.748</td>
<td>0.000</td>
<td>0.055</td>
<td>0.000</td>
<td>0.033</td>
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</table>

* adjusted R² = 0.725

325
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<tr>
<th>STEP</th>
<th>INDEP. VARIABLE</th>
<th>F1</th>
<th>R</th>
<th>R^2</th>
<th>ΔR^2</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
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<td>POST-TEST 2</td>
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<td>0.777</td>
<td>0.604</td>
<td>0.604</td>
<td>294.154</td>
<td>412.772</td>
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<td>(0.001)</td>
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<td>(0.001)</td>
<td>(SS)</td>
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<tr>
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<td>INTELL</td>
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<td>0.051</td>
<td>181.906</td>
<td>34.853</td>
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<td>(0.001)</td>
<td>(SS)</td>
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<td>(SS)</td>
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<tr>
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<tr>
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<td>0.723</td>
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<td>0.000</td>
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<td>4.100</td>
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<td></td>
<td>(S)</td>
<td>(0.492)</td>
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<tr>
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<td>D12</td>
<td>0.120</td>
<td>0.855</td>
<td>0.732</td>
<td>0.001</td>
<td>0.000</td>
<td>0.683</td>
<td>0.099</td>
</tr>
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<td></td>
</tr>
<tr>
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<td>D8</td>
<td>2.308</td>
<td>0.856</td>
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<td>0.000</td>
<td>0.000</td>
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<td></td>
<td></td>
<td>(NS)</td>
<td>(0.155)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D10</td>
<td>4.672</td>
<td>0.860</td>
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<td>0.007</td>
<td>0.000</td>
<td>4.784</td>
<td>4.421</td>
</tr>
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<td></td>
<td></td>
<td>(S)</td>
<td>(0.037)</td>
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</tr>
<tr>
<td>10</td>
<td>D3</td>
<td>0.469</td>
<td>0.860</td>
<td>0.739</td>
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<td>72.752</td>
<td>0.000</td>
<td>0.469</td>
</tr>
<tr>
<td></td>
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<td>(0.494)</td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.494)</td>
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</tr>
<tr>
<td></td>
<td>D5</td>
<td>1.122</td>
<td>0.861</td>
<td>0.741</td>
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<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
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<td>(0.291)</td>
<td></td>
<td></td>
<td></td>
<td>(NS)</td>
<td>(0.291)</td>
<td></td>
</tr>
</tbody>
</table>

*adjusted R^2 = 0.717*
10.7.2 Analysis of Post-test 2 Contd.

The D10 class now performed significantly below the average, contributing about 1% to the variance in the dependent variable. Again there is no obvious reason for this drop in performance.

.8 Prediction of the Final Mark for W.H.S.

Table 10-17 shows the result of a multiple regression analysis using a selected list of independent variables to predict the final mark (FM) at the end of the year. Some subjects did not sit for the end of year exam and were dropped from the analysis leaving in all 195 subjects.

The Post-test 2 score is by far the most important predictor and accounts for \( 0.604 \times 100 = 81.5\% \) of the explained variance when entered on the first step.

Intelligence is also very significant when entered immediately afterwards on step two, but is not significant if entered last (statistic F4). Reading age is not significant when entered on step four (after Post-test 2, intelligence and MA), nor when entered last.

On the other hand MA and P-Two remain strong predictors when entered on step three and seven respectively and also when entered last. Subjects considered to be high in mathematical aptitude and in interest and concentration perform significantly better than other subjects, even after adjustment for the effects of Post-test 2 scores and intelligence.

Sex is not a significant source of variance with boys and girls performing equally well after adjustments are made for the major covariates.

It is interesting to note that, once again, the D9 class performed significantly worse than the other classes and the D10 class performed significantly better.∗

The net effect of all the class variables entered on step nine is given by

\[
F = \frac{(0.739 - 0.723)/7}{(1 - 0.741)/177} = 1.562
\]

∗ Actually "worse" and "better" is in relation to class one which corresponds to D6, the dummy variable dropped from the analysis by the computer.
10.8 Prediction of the Final Mark for W.H.S. Contd.

which is not significant at the 0.05 level. Thus overall class makes no significant contribution to the variance in FM although individual classes do.

Method is making nearly no contribution at all when entered last as we would expect. For method the overall F is only

\[ F = \frac{(0.741 - 0.739)/2}{(1 - 0.741)/177} \]

9 Analysis of the Three Groups

It is informative to look at each group independently and see whether consistent patterns emerge and whether these agree with the analysis of the overall population.

Table 10-18 shows the significance of F values and \(R^2\) values for the independent variables listed. Only one Table is presented for brevity rather than the usual three. The Post-test 1 score is taken as the dependent variable and results are shown with and without the personality variables included in the analysis.

Without P-One and P-Two included the results are very similar except that the Pre-test is not accounting for so much of the variance for the booklet-group, and intelligence is not so significant for the microfiche-group as for the other groups.

When P-One and P-Two are included, the latter takes up variance from intelligence or Pre-test or both, and for the microfiche-group takes up the effects of intelligence altogether. It also accounts for an additional 3-4% of the variance to that accounted for by the other independent variables. P-One is nowhere significant and so its additional contribution to the explained variance would be negligible.

Age is nowhere significant, and although sex is also nowhere significant there is a suggestion that boys perform slightly better than girls in the booklet situation after the effects of P-Two are taken into account.

Interest and concentration (P-Two) is significant in all situations even after adjusting for other co-variates. For the microfiche situations, interest and concentration are apparently more important than intelli-
<table>
<thead>
<tr>
<th>GROUP</th>
<th>PREFST</th>
<th>INTELL</th>
<th>AGE</th>
<th>P-ONE</th>
<th>P-TWO</th>
<th>SEX</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>LECTURE (N = 67)</td>
<td>0.006</td>
<td>0.005</td>
<td>0.495</td>
<td>0.463</td>
<td>0.013</td>
<td>0.861</td>
<td>0.610</td>
</tr>
<tr>
<td>MICROFICHE (N = 63)</td>
<td>0.001</td>
<td>0.521</td>
<td>0.124</td>
<td>0.353</td>
<td>0.004</td>
<td>0.900</td>
<td>0.666</td>
</tr>
<tr>
<td>BOOKLETS (N = 66)</td>
<td>0.023</td>
<td>0.001</td>
<td>0.290</td>
<td>0.539</td>
<td>0.050</td>
<td>0.083</td>
<td>0.481</td>
</tr>
<tr>
<td>LECTURE (N = 68)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.419</td>
<td>-</td>
<td>-</td>
<td>0.844</td>
<td>0.570</td>
</tr>
<tr>
<td>MICROFICHE (N = 67)</td>
<td>0.001</td>
<td>0.053</td>
<td>0.385</td>
<td>-</td>
<td>-</td>
<td>0.250</td>
<td>0.635</td>
</tr>
<tr>
<td>BOOKLETS (N = 66)</td>
<td>0.010</td>
<td>0.001</td>
<td>0.282</td>
<td>-</td>
<td>-</td>
<td>0.354</td>
<td>0.429</td>
</tr>
</tbody>
</table>

TABLE 10-18
COMPARISON OF THREE W.H.S. GROUPS (FROM SPSS ANOVA ANALYSIS)
SIGNIFICANCE OF F VALUES
DEPENDENT VARIABLE = POST-TEST I SCORE
10.9 Analysis of the Three Groups Contd.

gence per se, and some of the students apparently performed well if their interest was high enough.

For the booklet situation only about 50% of the variance could be accounted for using the independent variables shown, whereas over 60% could be accounted for in the other two situations. Extraneous variables thus appear to operate slightly more effectively in the booklet situation.

When comparing Table 10-18 with the composite data in 10-11 it is necessary to remember that N is now only about one third of the value it is in the latter. Thus in Table 10-11 (a), Pre-test, intelligence and P-Two are all becoming significant to the 0.001 level. However, overall the results are quite consistent, with P-One and P-Two accounting for an additional 2 - 5% of the variance, the 'explained' portion of which has dropped back to about 50 - 65% overall.

10 Times Taken by Self-Paced Subjects

This report has already included a full discussion of time taken as an independent variable for mathematical and non-mathematical topics given at Kilkenny College of Further Education (Sections 8 and 9). For the W.H.S. project no attempt was made to record the times taken at self-paced instruction by individual subjects, but the number of subjects working at various times were recorded.

Table 10-19 shows the percentages of subjects using microfiche finished after one instructional period, one and a half, one and three-quarters and two instructional periods respectively, averaged over the four colour groups. The results are represented graphically in Figure 10-10.

<table>
<thead>
<tr>
<th>TABLE 10-19</th>
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</thead>
<tbody>
<tr>
<td>PERCENTAGES FINISHING (approx)</td>
</tr>
<tr>
<td>LESSON PERIODS</td>
</tr>
<tr>
<td>% FINISHED (approx)</td>
</tr>
</tbody>
</table>
10-15% didn’t finish in time

30% had finished halfway through second lesson

40-50% had finished 2/4 way through second lesson
10.10 Times Taken by Self-Paced Subjects Contd.

By "finished" is meant that the subjects had worked entirely through the self-paced programme from beginning to end. The subject was then given the choice of going through the programme again or going on with other work. The above percentages probably understate the true figures as some subjects did not immediately inform the supervisors when they finished the programme but went back and worked through some of the more difficult parts of their own accord.

It is interesting to note that about 80 - 90% of subjects had finished the programme by the end of the second period, although about 50% were still working three-quarters of the way through that period. The possibility of a "band-wagon" effect cannot be ruled out, but the self-paced situation would seem to offer some economy of times vis-a-vis the lecture or lesson situation, since in the didactic situation two complete lesson periods are allocated to this work.

11 Structure of the Tests (item-analysis)

Figures 10-11 (a) and 10-11 (b) show the number of correct responses for each of the 20 items or questions in the Pre-test and Post-test 1.

Clearly many subjects had a considerable prior-knowledge of the concepts tested by items 2, 3, 11, 12, 14, 15 and 16 and very little prior-knowledge of items 1, 5, 6, 7, 8, 9, 10, 13, 17, 18, 19 and 20. For items 1, 5, 6, 7, 8, 9, 10, 18, 19 and 20 the Pre-test scores were nearly nil for all subjects.

The application of the three teaching methods were about equally effective in raising the mean scores on all items. In fact, the inter-item score profiles are remarkably consistent from one teaching method to the next. All subjects found items 6, 9 and 13 difficult on the Post-test while scores for 18, 19 and 20 were generally well down, all of these items had been quite beyond most subjects in the Pre-test.

A study of the conceptual and verbal content of the items suggested the reasons for the discrepancies in difficulty level. Items 6 and 13 for example require a sound understanding of decimals while items 6 and 9 also ask subjects to find what % of one quantity is another rather than the more usual what % is one quantity of another. Questions 18, 19 and 20 all require an ability to manipulate percentages using several operations.
Fig. 10 - "f(a)" Posttest

- Lecture
- Fiche
- Books
Fig. 10-11(b)
Pretest

Number of correct responses

- Lecture
- - - - Fiche
- - - - - Books
10.11 Structure of the Tests (item analysis) Contd.

From the point of view of the present discussion it is informative to analyse the gain in scores on items 1, 5, 6, 7, 8, 9, 10, 18, 19 and 20 i.e. on the items where all subjects scored nearly zero on the Pre-test. This measures the gain in new conceptual skills or understanding rather than an increase of pre-existing skills.

An analysis of covariance was carried out on the total post-test scores for items 1, 5, 6, 7, 8, 9, 10, 18, 19 and 20 using mathematical aptitude and intelligence as covariates, and sex and teaching methods as factors. Method and sex were not significant with F values of less than 0.10 after the covariates were adjusted for, while mathematical aptitude was significant to the 0.001 level with an F value of 28.17. The value of $R^2$ was 0.365 and for the method x sex interaction the F value was only about 0.331.

Thus new skills are learned as effectively by both sexes when taught by any one of the three methods. The determining factor is the mathematical aptitude (or intelligence) of the subject or, in other words, his or her pre-existing cognitive structures. The use of the branching programmes may cater more for individual differences in personality than does didactic teaching, but, in this case, as in most others discussed in this report, such effects are not reflected in the objective test results, possibly owing to the wide diversity of students, programmes with more branches were required.

This report cannot pursue this question in detail but learning theorists and educational technologists clearly have to determine in what ways various teaching methods and media can effectively mediate between the cognitive structures of the child and the assimilation of information by such structures. Over concentration on means of simply imparting information overlooks what further would refer to as the developmental aspect of education as distinct from the learning aspect. (139)

10.12 Summary

A single experimental run was carried out with junior secondary mathematics students at a large Adelaide suburban high school for the topic "Percentages". The population numbered about 230 who were randomly assigned to three groups, one of which received instruction in the topic by didactic teaching, another by self-paced learning using microtexts and the remaining group by self-paced learning using booklets.
10.12 **Summary Contd.**

It was found that:

(a) Although the initial groups did show some differences on relevant variables these were not significant at the .05 level.

(b) Scores on Post-tests 1 and 2 depended on Pre-test scores, intelligence, "interest and concentration", mathematical aptitude and reading age. They were not generally significantly dependent on sex, teaching method, age or "introversion" as assessed by the regular classroom instructors.

(c) Method did become significant when processed first in the analysis of Post-test 1 but this was due to the initial group differences and only accounted for 2% of the variance in the Post-test 1 scores. When processed last, method only accounted for about 0.5% or less of the variance is Post-tests 1 and 2.

(d) About 60 - 75% of the variances in Post-test 1 and Post-test 2 could be accounted for using all of the available data. It was also possible to account for 75% of the variance in the final marks.

(e) "Interest and concentration" seem to play a greater role than intelligence in the microfiche situation after adjustments are made for Pre-test scores.

(f) The structure of the test-item results was quite consistent from method to method. No significant relationship was found between level of difficulty of items on Post-test 1 and method.

(g) Analysis of covariance and multiple regression analysis when used to analyse Post-test 1 and Post-test 2 produced similar results.

(h) The self-paced situation involved a considerable saving in time for most students without a decremental effect on test results.
11. DISCUSSION OF EMPIRICAL RESULTS IV : SURVEY DATA A - Students' Preference for Teaching Situations

Thus far the performance of several populations of subjects in various learning situations has been investigated. Some fairly sophisticated statistical procedures have been used to show the inter-relationships between a great number of variables, some attributable to, e.g. sex, intelligence and others, subject to experimental manipulation, e.g. method.

Yet this is only part of the overall picture, for it is also important to know how people think about a situation, to determine their "subjective" responses as well as those responses which can be measured on objective tests.

How a subject perceives a situation will usually not be static but part of an on-going dynamic interactional process. Thus his response to a question, oral or written, will not indicate a fixed attribute or attitude but will be a function of his overall view or perception of the situation, which will be fluid and subject to continual re-definition.

Considerable care is therefore required in interpreting survey or questionnaire data. Such data should be recognized as unstable and fluid and certainly not context-free. For example, the interviewer may, unintentionally, elicit the responses ha consciously or subconsciously desires and the interviewee may quickly learn the correct response and oblige accordingly. This may have affected the results obtained in the 1975 pilot study in which each subject was personally interviewed, see Section 6.3.

In the 1976 survey a number of questionnaires were devised, one each for:

(a) students at Kilkenny College of Further Education (Preparatory Mathematics and Stage 1 Technical Certificate students).
(b) students at Woodville High School.
(c) all teachers who cooperated in the research.

1 Survey Results for Preparatory Mathematics and Stage 1 Mathematics and Science Classes

1 Preparatory Mathematics

The questionnaire used is presented in Appendix 7. This was drawn up very early in the year and in retrospect could have been
11.1.1 Preparatory Mathematics Contd.

considerably improved. However, it was decided to retain it throughout the year for Kilkenny College of Further Education students to facilitate comparison and pooling of data gathered.

The Preparatory Mathematics results are summarized in Table 11-1, where (a) to (h) are the 16 possible learning situations presented for consideration. In all only about 40 Preparatory Mathematics subjects responded to the survey and so that data may not be fully representative of the entire population. The situations were:

(a) Lectures and tutorials as they were currently conducted.
(b) Lectures and tutorials in smaller classes of about 10 - 12 students.
(c) Microfiche viewers available two nights a week for three hours at a fixed time, for individual use.
(d) Microfiche viewers available two nights a week for three hours at a fixed time, for use in small groups of 3 - 4 students.
(e) Microfiche viewers available every night, for individual use.
(f) Microfiche viewers available every night, for use in small groups of about 3 - 4 students.
(g) Individual use of booklets which could be taken home.
(h) Small groups of 3 - 4 students with booklets which could be taken home.

(a\textsuperscript{1}) Microfiche viewers with an academic tutor available two nights a week for three hours at fixed times, for individual use.
(b\textsuperscript{1}) Microfiche viewers with an academic tutor available two nights a week for three hours at fixed times, for use in small groups of 3-4 students.
(c\textsuperscript{1}) Microfiche viewers with an academic tutor available every night, for individual use.
(d\textsuperscript{1}) Microfiche viewers with an academic tutor available every night for use in small groups of 3-4 students.

(e) Individual use of books which could be taken home, with an academic tutor available.

(f) Small groups of 3 - 4 students with booklets that could be taken home, with an academic tutor available.

(g) Lectures and tutorials in smaller groups of 10 - 12 students.

(h) Lectures and tutorials as they are currently conducted.

In question 7 of the questionnaire the subject was asked to list his preferences 1 to 8 for the options (a) to (h). In question 8 he was asked to list his preferences 1 to 8 for options (a') to (h').

In question 8 all options differed from the corresponding options in question 7 by the inclusion of the academic tutor with two exceptions. The exceptions were (g') and (h') which were the same as (b) and (a) respectively.

The purpose of this arrangement was:

(i) to determine whether the subjects' preferences would change with the availability of an academic tutor or whether they would retain similar preferences with or without the availability of the tutor.

(ii) to determine whether subjects would exhibit a preference for working as individuals or in small groups in the various learning situations, with or without the presence of an academic tutor.

(iii) to check whether some subjects simply numbered the preferences randomly down or up the lists of options. In fact, as far as could be judged the subjects made conscientious choices and did not simply number their preferences sequentially.

(iv) to determine overall preferences for the various learning situations.

The totals at the bottom of each column are not exactly the same as some respondents did not indicate a full list of preferences. All respondents however indicated some preferences.
### TABLE 11-1

**PREPARATORY MATHEMATICS - PREFERENCES FOR TEACHING SITUATIONS**

#### TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>PREF.</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
<th>a¹</th>
<th>b¹</th>
<th>c¹</th>
<th>d¹</th>
<th>e¹</th>
<th>f¹</th>
<th>g¹</th>
<th>u¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>2</td>
<td>3</td>
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<td>0</td>
<td>3</td>
<td>4</td>
<td>19</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>12</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>14</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>3</td>
<td>9</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>16</td>
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<tr>
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<td>7</td>
<td>5</td>
<td>5</td>
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<td>10</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>17</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>9</td>
<td>9</td>
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<td>7</td>
<td>18</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>8</td>
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<td>7</td>
<td>14</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>6</td>
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<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>11</td>
<td>6</td>
<td>12</td>
<td>4</td>
<td>9</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>42</td>
<td>43</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>39</td>
<td>39</td>
<td>41</td>
<td>40</td>
<td>40</td>
<td>41</td>
<td>40</td>
<td>42</td>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

The overwhelming preference is clearly for the teaching situation especially in smaller groups of 10 - 12 students. Without an academic tutor not one single respondent gave one of the four microfiche options as a first preference. With an academic tutor available about 10% of the respondents gave one of the microfiche options as a first preference.

The preference for the teaching situation is too pronounced to warrant much detailed analysis of Table 11-1. But an additional perspective can be obtained by combining the various teaching options into three simple categories "lecture", "microfiche" and "booklets" and the preferences into the same three categories or "situation".

The results are shown in Tables 11-2 (a) and 11-2 (b). The subjects' preferences are now ranked simply 1, 2, or 3 according to the order in which he first chose a given teaching category.
11.1.1 Preparatory Mathematics Contd.

TABLE 11-2 (a)

PREFERENCES FOR TEACHING SITUATIONS WITHOUT AN ACADEMIC TUTOR

TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>PREFERENCE</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST</td>
<td>43</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>SECOND</td>
<td>2</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>THIRD</td>
<td>1</td>
<td>20</td>
<td>18</td>
</tr>
</tbody>
</table>

This shows, of the 46 respondents who gave a first preference 93% chose the lecture situation, 7% chose booklets and 0% chose microfiche; of the 39 respondents who gave a second preference 5% chose the lecture situation, 49% chose microfiche and 46% chose booklets; of the 39 respondents who gave a third preference 3% chose the lecture situation (i.e. only one respondent), 51% chose microfiche and 46% chose booklets.

Surprisingly the presence of an academic tutor did not drastically change the overall response pattern. Table 11-2 (b) shows the response pattern with an academic tutor available for the self-paced situation.

TABLE 11-2 (b)

PREFERENCES FOR TEACHING SITUATIONS WITH AN ACADEMIC TUTOR

TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>PREFERENCE</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST</td>
<td>34</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>SECOND</td>
<td>7</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>THIRD</td>
<td>3</td>
<td>25</td>
<td>13</td>
</tr>
</tbody>
</table>
11.1.1 Preparatory Mathematics Contd.

The lecture situation still receives 76% of the first preferences but there is a decided shift towards the self-paced situations. Of the latter, books have the edge over microfiche in both first and second preferences.

An $\chi^2$ test cannot be directly applied to the above composite tables as the responses are not independent. However, one can test the strength of the association between teaching situation and one of the orders of preference. If there was no association then about 15 respondents would give each teaching situation their first preference and we can construct a simple contingency table thus:

TABLE 11-3

PERCENTAGE FIRST PREFERENCE (WITHOUT ACADEMIC TUTOR)

<table>
<thead>
<tr>
<th>Teaching Situation Preferred</th>
<th>Lecture</th>
<th>Microfiche</th>
<th>Booklets</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;EXPECTED&quot;</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>OBSERVED</td>
<td>42</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

$$\chi^2 = \frac{(42 - 15)^2}{15} + 15 + \frac{(15 - 3)^2}{15} = 77$$

For two degrees of freedom this shows a highly significant preference for the lecture situation (significant to beyond 0.001 level).

When an academic tutor is included $\chi^2 = 37$ showing a still strong preference for the lecture situation but with some slight shift of preference to the self-paced situations.

The above data shows that the Preparatory Mathematics subjects, if given a choice, strongly prefer the conventional teaching situation, even when an academic tutor is made available in the self-paced situations. On the other hand, when asked to indicate a second preference, roughly equal numbers selected microfiche and booklets.
11.1.1 **Preparatory Mathematics** \(\text{Contd.}\)

Clearly these subjects regard microfiche or programmed-booklets as a possible support or "back up" to the conventional lecture and not as a replacement or alternative.

Looking at the last preference in Table 11-1, when a tutor was available there seems to be a preference against working as individuals in both self-paced situations. In fact the subjects did seem to enjoy working together in small groups on the microfiche viewers whatever their overall preference for teaching method.

.2 **Stage 1 Mathematics and Science**

Once again in the questionnaire, subjects were presented with two sets of teaching situations, one set of eight without an academic tutor and a second set of eight with an academic tutor available for the self-paced situations (see Section 11.1.1). The results are shown in Table 11-4.

<table>
<thead>
<tr>
<th>TABLE 11-4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STAGE 1 MATHEMATICS AND SCIENCE PREFERENCES FOR TEACHING SITUATIONS</strong></td>
</tr>
<tr>
<td>TEACHING SITUATION PREFERRED</td>
</tr>
</tbody>
</table>

| PREF. | a | b | c | d | e | f | g | h | a|-- | b|-- | c|-- | d|-- | e|-- | f|-- | g|-- | h|-- |
|-------|---|---|---|---|---|---|---|---|---|----|----|---|----|---|----|---|----|---|----|---|----|
| 1     | 22| 45| 3 | 4 | 4 | 1 | 4 | 8 | 7 | 8  | 16 | 7  | 3 | 9  | 30| 13 |
| 2     | 10| 20| 8 | 4 | 12| 6 | 6 | 4 | 9 | 8  | 6  | 9  | 7 | 3  | 19| 25 |
| 3     | 10| 7 | 10| 7 | 13| 19| 11| 11| 11| 10 | 14 | 15 | 3 | 14 | 9 | 11 |
| 4     | 6 | 4 | 16| 16| 15| 11| 7 | 13| 12| 11 | 10 | 16 | 20| 3 | 7 | 9  |
| 5     | 5 | 6 | 17| 16| 16| 12| 9 | 5 | 16| 11 | 17 | 10 | 10| 8 | 5 | 8  |
| 6     | 4 | 2 | 14| 18| 15| 24| 2 | 6 | 11| 16 | 9  | 19 | 10| 14| 4 | 6  |
| 7     | 4 | 4 | 12| 12| 8 | 9 | 25| 12| 14| 12 | 9  | 7  | 16| 16| 10| 4  |
| 8     | 7 | 1 | 6 | 10| 5 | 6 | 23| 28| 7 | 12 | 6  | 7  | 19| 21| 3 | 11 |
| TOTAL | 88| 89| 87| 87| 88| 88| 87| 87| 87| 88 | 87 | 90 | 88| 88| 87| 87 |

\[\text{Page 345}\]
11.1.2 Stage I Mathematics and Science  Contd.

90 subjects responded but again not every subject gave a full list of preferences so that numbers at the bottoms of the columns are slightly different.

In this case there is a marked difference in response patterns between situations (a) and (h) and situations (a') and (h'). Whereas for the Preparatory Mathematics subjects the presence or absence of an academic tutor only had a marginal effect, there is now a strong swing towards the self-paced situations when an academic tutor is made available.

As before it is informative to combine the various lecture, microfiche and booklet situation into just three categories or "combined situations" and to only consider three preferences, one for each combined situation. Thus, for example no distinction is drawn between subjects preferring microfiche as individuals and microfiche as small groups.

Tables 11-5 (a) and 11-5 (b) show the results thus obtained.

**TABLE 11-5 (a)**

PREFERENCES FOR TEACHING SITUATIONS WITHOUT AN ACADEMIC TUTOR

<table>
<thead>
<tr>
<th>PREFERENCE</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST</td>
<td>67</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>SECOND</td>
<td>13</td>
<td>45</td>
<td>29</td>
</tr>
<tr>
<td>THIRD</td>
<td>10</td>
<td>30</td>
<td>46</td>
</tr>
</tbody>
</table>

**TABLE 11-5 (b)**

PREFERENCES FOR TEACHING SITUATIONS WITH AN ACADEMIC TUTOR

<table>
<thead>
<tr>
<th>PREFERENCE</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST</td>
<td>43</td>
<td>38</td>
<td>12</td>
</tr>
<tr>
<td>SECOND</td>
<td>24</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td>THIRD</td>
<td>18</td>
<td>21</td>
<td>47</td>
</tr>
</tbody>
</table>
11.1.2 Stage 1 Mathematics and Science Contd.

The first preference patterns are shown in Table 11-6 for situations with or without an academic tutor. $\chi^2$ is also shown for the departure from a rectangular preferential pattern (where about 30 subjects gave first preference to each situation).

**TABLE 11-6**

FIRST PREFERENCE PATTERNS ($\%$'s) WITH AND WITHOUT AN ACADEMIC TUTOR

<table>
<thead>
<tr>
<th>ACADEMIC TUTOR</th>
<th>LECTURE (%)</th>
<th>MICROFICHE (%)</th>
<th>BOOKLETS (%)</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHOUT</td>
<td>74 (%)</td>
<td>13 (%)</td>
<td>13 (%)</td>
<td>67</td>
</tr>
<tr>
<td>WITH</td>
<td>46 (%)</td>
<td>41 (%)</td>
<td>13 (%)</td>
<td>18</td>
</tr>
</tbody>
</table>

Without an academic tutor about three-quarters of the subjects gave the lecture situation their first preference while the others were about equally split between the two self-paced situations. With an academic tutor included, the preference for microfiche markedly increased to almost that for the lecture situation, but the preference for programmed-booklets remained unchanged. These results are shown graphically in Figures 11-1 (a) and 11-1 (b).

The high value for $\chi^2$ without an academic tutor shows the high preference for the lecture situation in that circumstance. When an academic tutor is included $\chi^2$ has dropped from 67 to 18 but there is still a very strong preference for both lecture and microfiche vis-à-vis booklets.

Tables 11-5 (a) and 11-5 (b) can also be used to determine the numbers of respondents giving the various situations first or second preferences. The results are shown in Table 11-7.

When offered the choice of the three situations only about 45% of the respondents gave booklets as their first or second preferences, with or without an academic tutor. About 60% gave microfiche as their
Without Academic Tutor

<table>
<thead>
<tr>
<th>Preference</th>
<th>Lectures</th>
<th>Fiche</th>
<th>Books</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>67</td>
<td>12</td>
<td>12</td>
<td>91</td>
</tr>
<tr>
<td>Second</td>
<td>13</td>
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<td>87</td>
</tr>
<tr>
<td>Third</td>
<td>10</td>
<td>30</td>
<td>46</td>
<td>86</td>
</tr>
</tbody>
</table>

Fig. 11 - 1(a)
Fig. 11-1(b)

With Academic Tutor

<table>
<thead>
<tr>
<th>Preference</th>
<th>Lecture</th>
<th>Fiche</th>
<th>Books</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>43</td>
<td>38</td>
<td>12</td>
<td>93</td>
</tr>
<tr>
<td>Second</td>
<td>24</td>
<td>32</td>
<td>31</td>
<td>87</td>
</tr>
<tr>
<td>Third</td>
<td>18</td>
<td>21</td>
<td>47</td>
<td>86</td>
</tr>
</tbody>
</table>
first or second preferences, without an academic tutor and about 70% with an academic tutor. The presence of an academic tutor has only a marginal effect effect when first and second preferences are combined.

In interpreting these results it should be noted that only about 12 of the respondents had received exposure to programmed-booklets, but during the experimental period most had received exposure to microfiche and, of course, conventional teaching at some stage. Some part-time Stage 1 Mathematics students had only received exposure to conventional teaching but these were excluded from the survey. At the time they were surveyed about 6 full-time students had received no exposure to microfiche but had to booklets.

Thus some bias was possibly introduced against booklets. Had all respondents received an opportunity to work through booklets possibly the proportion giving booklets their first or second preference would increase. On the other hand, although the numbers are too small to be conclusive only 3 (or 25%) of the 12 respondents who had received exposure to booklets gave booklets their first or second preference with or without the presence of an academic tutor.

With the academic tutor options the spread of responses is sufficient to enable some observations to be made on selected attributive variables.

TABLE 11-7
NUMBER OF Respondents giving a teaching situation first or second preference

<table>
<thead>
<tr>
<th>TEACHING SITUATION PREFERRED</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITH</td>
<td>67</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>WITHOUT</td>
<td>80</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

With or without the presence of an academic tutor.
11.1.2 Stage 1 Mathematics and Science Contd.

(1) Effects of age

Table 11-8 shows the first preferences of respondents with ages above and below the median (taken to be 20 years) for the population. As the data is now independent a $\chi^2$ value can be calculated for the table to indicate the degree of association between the attributive variable, age and first preference.

**TABLE 11-8**

**FIRST PREFERENCES OF TEACHING SITUATIONS WITH AN ACADEMIC TUTOR**

(ATTRIBUTIVE VARIABLE = AGE):*

TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE &gt; MEDIAN</td>
<td>21</td>
<td>19</td>
<td>7</td>
<td>0.33</td>
</tr>
<tr>
<td>AGE &lt; MEDIAN</td>
<td>21</td>
<td>16</td>
<td>5</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>42</td>
<td>35</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

* age data was available for only 89 respondents

$\chi^2$ is not significant at the 0.05 level for two degrees of freedom. Thus there is no significant relationship between chronological age and choice of teaching situation.

(II) Effects of Marital Status

As it was thought possible that married students, owing to their family commitments, might have different study habits from unmarried students, their preferences for the different teaching methods were investigated.

Table 11-9 shows first preferences of teaching method for the two categories of marital status considered. The data was not sufficient to distinguish between sub-categories such as 'married' and 'married with children'.

There are fewer married respondents than single and when account is taken of this, there is no significant difference in the preference patterns.
TABLE 11-9
FIRST PREFERENCE OF TEACHING SITUATION WITH AN ACADEMIC TUTOR
(ATTRIBUTIVE VARIABLE = MARITAL STATUS)

TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLE</td>
<td>26</td>
<td>27</td>
<td>9</td>
<td>1.47</td>
</tr>
<tr>
<td>MARRIED</td>
<td>17</td>
<td>11</td>
<td>3</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>43</td>
<td>38</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

(iii) Effects of Intelligence

Table 11-10 shows first preferences of teaching method for respondents with IQ above and below the mean for the experimental population.

TABLE 11-10
FIRST PREFERENCE OF TEACHING SITUATION WITH AN ACADEMIC TUTOR
(ATTRIBUTIVE VARIABLE = IQ)*

TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ &gt; MEAN</td>
<td>26</td>
<td>16</td>
<td>5</td>
<td>2.67</td>
</tr>
<tr>
<td>IQ &lt; MEAN</td>
<td>16</td>
<td>19</td>
<td>7</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>42</td>
<td>35</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

* IQ data was available for only 89 respondents

$\chi^2$ is not significant at the 0.05 level but there is some slight tendency for brighter subjects to give the lecture situation their first preference.
11.1.2 Stage 1 Mathematics and Science Contd.

(iv) Effects of Part or Full-Time Status

The results for these categories are shown in Table 10-11.

**TABLE 10-11**

FIRST PREFERENCE OF TEACHING SITUATION 1: 1 AN ACADEMIC TUTOR

| (ATTRIBUTIVE VARIABLE = PART OR FULL-TIME STATUS) |
|-------------------------------|---------|---------|
| TEACHING SITUATION PREFERRED  | LECTURE | MICROFICHE | BOOKLETS | \( \chi^2 \) |
| FULL-TIME                    | 15      | 8        | 1        | 4.21    |
| PART-TIME                    | 28      | 30       | 11       | (NS)    |
| TOTAL                        | 43      | 38       | 12       |         |

\( \chi^2 \) is still not significant at the 0.05 level but there is apparent; some tendency for part-time respondents to prefer the self-paced situations more than the full-timers. This might be expected as the part-timers usually held full-time jobs away from the College and possibly saw self-paced instruction as a way of freeing them from complete dependence upon lectures.

(v) Effects of Discipline

The response pattern gathered from subjects after the science topics is compared with the response pattern gathered from subjects after the mathematical topics in Table 11-12. The science programmes were of different design from the mathematical programmes and some differential effects were hypothesized upon the basis of this difference.

Some of the science respondents had also previously responded to the questionnaire after the mathematics experiment. Thus far these returns have been excluded from this analysis and only

* The mathematical programmes were branched but the science programmes were not, for example.
11.1.2 Stage 1 Mathematics and Science Contd.

(v) Effects of Discipline Contd.

the results for first-time respondents retained. In Table 11-12, however, these respondents are "counted twice", in order to bring out any "topic effects". In fact $\chi^2 = 0.33$, so no topic effects are evident.

TABLE 11-12
FIRST PREFERENCE OF TEACHING SITUATION WITH AN ACADEMIC TUTOR
(FOR MATHEMATICS AND SCIENCE TOPICS)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATHEMATICS</td>
<td>37</td>
<td>35</td>
<td>12</td>
<td>0.33</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>14</td>
<td>13</td>
<td>3</td>
<td>(NS)</td>
</tr>
</tbody>
</table>

Summarizing the results for Stage 1 Mathematics and Science it can be said that:

(a) the lecture situation is strongly preferred if no academic tutor is made available but the lecture and microfiche self-paced situations are about equally preferred if a tutor is made available.

(b) many more subjects gave microfiche and the lecture situations their first or second preferences than programmed-booklets.

(c) there is no significant association between preference of teaching situation and chronological age, marital status, intelligence or whether the programme is scientific or purely mathematical. It had been felt that married and/or part-time subjects, who would tend also to be older than the average, might prefer the self-paced situations to conventional lectures. Possibly part-time subjects do conform to such expectations but the value of $\chi^2$ did not reach significance at the 0.05 level for the numbers of subjects involved.
11.1.2 Stage 1 Mathematics and Science Contd.

In the survey (there was only 24 full-timers amongst the respondents).

It is difficult to place high reliance upon $\chi^2$ values for data with only one subject in one cell (Table 11-11). Thus the discussion is intended to be indicative rather than definitive.

11.2 Woodville High School: Survey Results

The questionnaire involved is shown in Appendix 7. Unlike with the Kilkenny College of Further Education students, all of whom were adults, the teachers guided the respondents through the questionnaire carefully explaining the meaning of each question.

Emphasis was no longer placed upon respondents' orders of preference as with questions 7 and 8 of the Kilkenny College of Further Education questionnaire. Rather, respondents were asked to simply to indicate which teaching method they felt they liked 

\textbf{best} and \textbf{least} (questions 4 and 5 respectively). As there were three principal categories of method - lecture (or "teacher"), microfiche and booklets - these responses enabled the researchers to rank the method categories in order of preference.

In question 6 the respondent was asked which of five methods he or she would like to see used in the school. These methods now included the possibility of self-paced learning with a teacher to answer questions - in fact, very close to the actual state of affairs during the experimental procedure. Thus the five methods were:

(a) teacher only
(b) microfiche by itself
(c) microfiche with teacher to answer questions
(d) booklets only
(e) booklets with teacher to answer questions

Although respondents were asked to indicate their order of preference in question 6, as expected very few did so. The researchers were mainly interested in their choice of most preferred option and whether the addition of the "mixed options" had created a pattern of responses different from that given to questions 4 and 5.

With about 230 respondents available together with considerable background
data for each, it was possible to carry the analysis further than with
the Kilkenny College of Further Education subjects. There were about
70 - 80 respondents from each teaching situation enabling a reasonably
valid comparison to be drawn regarding the popularity of the situations,
and the researchers were able to investigate the possible causes for such
popularity or lack of same.

Table 11-13 summarizes the composite data for preferred method, taken
from responses to Question 4.

TABLE 11-13
FIRST PREFERENCES
TEACHING SITUATION PREFERRED

<table>
<thead>
<tr>
<th>ALLOCATED GROUP</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEACHER</td>
<td>57</td>
<td>30</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MICROFICHE</td>
<td>25</td>
<td>45</td>
<td>0</td>
<td>97.3</td>
</tr>
<tr>
<td>BOOKLETS</td>
<td>19</td>
<td>22</td>
<td>34</td>
<td>0.001</td>
</tr>
<tr>
<td>TOTAL</td>
<td>101 (43%)</td>
<td>97 (42%)</td>
<td>35 (15%)</td>
<td></td>
</tr>
</tbody>
</table>

Thus of the 88 (57 + 30 + 1) respondents who had been given the conven-
tional lesson, 57 preferred that method, 30 preferred microfiche and only
1 preferred booklets. Of the 70 respondents who had receive instruction
using a self-paced programme on microfiche, 25 preferred the conventional
lesson or teacher situation, 45 preferred microfiche and none preferred
booklets. Of the 75 respondents who had received instruction using self-
paced programme in booklet form, 19 preferred the teacher situation, 22
microfiche and 34 the use of booklets.

The pattern of preferences is, thus strongly against books with only 35
out of 233 respondents giving books their first preference while nearly
equal numbers prefer the teacher and microfiche.

The high value of \( \chi^2 \) shown in Table 11-13 is indicative of a high associ­
ation between the group to which the respondent had been allocated and the
11.2 Woodville High School: Survey Results Contd.

respondents' preferences. Thus for these subjects the response pattern reflects, to a very significant degree, the method of instruction received i.e. lecture group members will tend to prefer the lecture, microfiche group members to prefer microfiche and booklet group members to prefer booklets.

To see whether this "carry over" effect differs significantly from group to group we can create two categories of respondents:

(a) with first preference the same as the method of instruction received during the experiment (category A)
(b) with first preference different from the method received during the experiment (category B).

The results are shown in Table 11-14.

**TABLE 11-14**

**FIRST PREFERENCES**

**ALLOCATED GROUP**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>57</td>
<td>45</td>
<td>34</td>
<td>7.4</td>
</tr>
<tr>
<td>B</td>
<td>31</td>
<td>25</td>
<td>41</td>
<td>(0.05)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>88</td>
<td>70</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

\( \chi^2 \) is greatly reduced but is still significant at the 0.05 level. Thus the distribution of preferences between categories A and B still differs significantly from group to group.

To investigate the origins of this distribution further it is informative to repeat the analysis with only two groups at a time and with those respondents selecting the remaining option dropped from the analysis. Thus Tables 11-15 (a) to (c) become the equivalents to Table 11-13, and Tables 11-16 (a) to (c) the equivalents of Table 11-14.
### TABLE 11-15 (a)

**FIRST PREFERENCES**

**TEACHING SITUATION PREFERRED**

<table>
<thead>
<tr>
<th>ALLOCATED GROUP</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEACHER</td>
<td>57</td>
<td>30</td>
<td>12.7</td>
</tr>
<tr>
<td>MICROFICHE</td>
<td>25</td>
<td>45</td>
<td>(0.001)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>82</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 11-15 (b)

**FIRST PREFERENCES**

**TEACHING SITUATION PREFERRED**

<table>
<thead>
<tr>
<th>ALLOCATED GROUP</th>
<th>TEACHER</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEACHER</td>
<td>57</td>
<td>1</td>
<td>47.2</td>
</tr>
<tr>
<td>BOOKLETS</td>
<td>13</td>
<td>34</td>
<td>(0.001)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>76</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 11-15 (c)

**FIRST PREFERENCES**

**TEACHING SITUATION PREFERRED**

<table>
<thead>
<tr>
<th>ALLOCATED GROUP</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICROFICHE</td>
<td>45</td>
<td>0</td>
<td>38.3</td>
</tr>
<tr>
<td>BOOKLETS</td>
<td>22</td>
<td>34</td>
<td>(0.001)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>67</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

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11.2 Woodville High School: Survey Results Contd.

Tables 11-15 (a) to 11-15 (c) again show a very significant association between allocated group and preferred teaching situation especially when booklets are included amongst the first preferences.

However when the data is rearranged to give Tables 11-16 (a) to 11-16 (c), $\chi^2$ drops nearly to zero for the case where the teacher and microfiche first preferences are considered and remains quite high, about 20, for the other two cases.

The "carry over" effect is thus of nearly the same magnitude for the teacher and microfiche situations but is far more pronounced for booklets than for either of the other two situations. On the other hand the "spill over" of preferences from the teacher and microfiche situations to the booklet situation is far less pronounced than the "spill over" in the reverse direction.

It is concluded that:

(a) there is a strong tendency for respondents to select the teaching situation to which they were allocated during the experiment.

(b) over and above this tendency there is a strong bias against booklets with only one respondent "spilling over" from the other situations to prefer booklets.

(c) preferences for the teacher and microfiche situations are nearly equally distributed with nearly the same "carry over" and "spilling over" effects for both.

The relationship between choice of teaching method and various attributive and other variables which could be hypothesized to affect the pattern of preference will now be investigated. In some cases the allocation of respondents to the various teaching situations will also be checked to ensure that no bias was introduced at that stage despite the randomization procedure.

1 Effect of Respondents' Sex

Tables 11-17 (a) and 11-17 (b) show respectively the allocation of boys and girls to the three groups and the preferences of the two sexes for the three teaching situations.
### TABLE 11-16 (a)

**FIRST PREFERENCES**

**ALLOCATED GROUP**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>57</td>
<td>45</td>
<td>~ 0.0</td>
</tr>
<tr>
<td>B</td>
<td>30</td>
<td>25</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>87</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 11-16 (b)

**FIRST PREFERENCES**

**ALLOCATED GROUP**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>57</td>
<td>34</td>
<td>19.8</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>19</td>
<td>(0.001)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>58</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 11-16 (c)

**FIRST PREFERENCES**

**ALLOCATED GROUP**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>45</td>
<td>34</td>
<td>21.1</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>22</td>
<td>(0.001)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>45</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

360
From Table 11-17 (a) we see that there is no sex bias introduced by the allocation procedure. However, Table 11-17 (b) suggests some association between sex and first preferences although it is not significant at the 0.05 level. Girls apparently tend to prefer the teacher situation and boys the microfiche situation while booklets are relatively unpopular with both sexes.

(II) Effect of Teacher's Sex

It was hypothesized that the sex of the teacher might influence a respondent's preferences. For example, boys might prefer the teacher option because the teacher is of the opposite sex and similarly for girls with male teachers. Tables 11-18 (a) and 11-18 (b) supply the
11.2 Wodville High School: Survey Results Contd.

(11) Effect of Teacher's Sex Contd.

relevant information to test this hypothesis where category A indicates "teacher of same sex as respondent" and category B, "teacher of opposite sex to respondent".

TABLE 11-18 (a)

ALLOCATION NUMBERS

ALLOCATED GROUP

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>42</td>
<td>33</td>
<td>35</td>
<td>0.0</td>
</tr>
<tr>
<td>B</td>
<td>46</td>
<td>37</td>
<td>40</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>88</td>
<td>70</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 11-18 (b)

FIRST PREFERENCES

TEACHING SITUATION

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>44</td>
<td>51</td>
<td>15</td>
<td>1.9</td>
</tr>
<tr>
<td>B</td>
<td>57</td>
<td>46</td>
<td>20</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>101</td>
<td>97</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

There is clearly no significant association between preference and respondents' sex vis-a-vis teacher's sex. "Teacher" here does not necessarily refer to the teacher who took the teacher group during the experiment but to the regular classroom instructor.

Tables 11-19 (a) and 11-19 (b) show the relevant data for teacher's sex without reference to the respondents' sex. It was hypothesized
11.2 Woodville High School: Survey Results Contd.

(11) Effects of Teacher's Sex Contd.

that male teachers could have been more or less effective in establishing rapport with their students of either sex, than female teachers.

TABLE 11-19 (a)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALE TEACHER</td>
<td>44</td>
<td>37</td>
<td>38</td>
<td>0.1</td>
</tr>
<tr>
<td>FEMALE TEACHER</td>
<td>44</td>
<td>33</td>
<td>37</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>88</td>
<td>70</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 11-19 (b)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALE TEACHER</td>
<td>49</td>
<td>50</td>
<td>20</td>
<td>0.8</td>
</tr>
<tr>
<td>FEMALE TEACHER</td>
<td>52</td>
<td>47</td>
<td>15</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>101</td>
<td>97</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

There is no significant association between sex of teacher and choice of teaching situation. Comparing Table 11-19 (b) and 11-18 (b) there is some evidence of a slight tendency for respondents to choose the teacher situation if the teacher is of the opposite sex but the numbers are far too small to be statistically significant.
11.2 Woodville High School: Survey Results Contd.

(III) Effect of Intelligence

Tables 11-20 (a) and 11-20 (b) check respectively the allocation of the groups and the association between intelligence and first preferences.

**TABLE 11-20 (a)**

**Allocation Numbers**

**Allocated Group**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ &gt; MEAN</td>
<td>37</td>
<td>36</td>
<td>36</td>
<td>0.7</td>
</tr>
<tr>
<td>IQ &lt; MEAN</td>
<td>43</td>
<td>32</td>
<td>36</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>80</td>
<td>68</td>
<td>72</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 11-20 (b)**

**First Preferences**

**Teaching Situation**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ &gt; MEAN</td>
<td>46</td>
<td>45</td>
<td>18</td>
<td>0.1</td>
</tr>
<tr>
<td>IQ &lt; MEAN</td>
<td>45</td>
<td>48</td>
<td>18</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>91</td>
<td>93</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

There is no association between intelligence and choice of teaching situation. Brighter students are just as likely to choose any one of the situations as are duller students.

Hereafter allocation tables will be omitted as $\chi^2$ is $< 1.0$ in each case.
11.2 Woodville High School: Survey Results Contd.

(iv) Effects of Reading Age Contd.
Table 11-21 shows relevant data for reading age.

<table>
<thead>
<tr>
<th>TABLE 11-21</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST PREFERENCES</td>
</tr>
<tr>
<td>TEACHING SITUATION</td>
</tr>
<tr>
<td>CATEGORY</td>
</tr>
<tr>
<td>RA &gt; MEAN:</td>
</tr>
<tr>
<td>RA &lt; MEAN</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Although $X^2 = 3.4$ is not significant at the 0.05 level it is high enough to suggest some slight association. Apparently respondents with reading difficulties tend to prefer the teacher situation to the self-paced situations, but larger numbers would be required to confirm this.

(v) Effects of P-One

It will be recalled that "P-One" is a measure of introversion - extroversion, as these terms are interpreted by the teachers. A high P-One score indicates a tendency towards introversion or psychological factors associated with introversion. Table 11-22 (a) shows the relevant data.

| TABLE 11-22 (a) |
| FIRST PREFERENCES |
| TEACHING SITUATION |
| CATEGORY | TEACHER | MICROFICHE | BOOKLETS | $X^2$ |
| P-ONE > MEAN | 61 | 48 | 15 | 5.1* |
| P-ONE < MEAN | 37 | 48 | 20 | (0.10) |
| TOTAL | 98 | 96 | 35 | |

* $X^2$ for allocation = 0.8

* The reliabilities of the personality measures are discussed in Appendix 2.1.
Woodville High School: Survey Results Contd.

(v) Effects of P-One Contd.

Although $\chi^2 = 5.1$ is not significant at the 0.05 level it is at the 0.10 level suggesting the possibility of some association. Apparently the more introverted respondents tend to prefer the teacher situation i.e. the status quo to the self-paced situations.

This effect can be brought out more strongly by only considering respondents with P-One values > 1 or < -1. The results are shown in Table 11-22 (b).

**TABLE 11-22 (b)**

**FIRST PREFERENCES**

**TEACHING SITUATION**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-ONE &gt; 1</td>
<td>19</td>
<td>8</td>
<td>3</td>
<td>8.1*</td>
</tr>
<tr>
<td>P-ONE &lt; -1</td>
<td>8</td>
<td>16</td>
<td>6</td>
<td>(0.02)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>27</td>
<td>24</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

* $\chi^2$ for allocation = 0.4

$\chi^2 = 8.1$ is now significant to the 0.02 level although numbers have been greatly reduced. Despite the inherent inaccuracies in the method of assessing P-One there seems definitely to be an association between extreme introversion - extroversion scores and preferences for teaching situation.

Effects of P-Two

"-Two" is a measure of "interest and concentration" a high score indicating poor interest and concentration or poor 'motivation'. If this term is roughly interpreted. Table 11 23 shows the results for this personality attribute.
Once again a very significant association exists between the personality measure and first preference, with a $\chi^2$ value of 8.2. More highly motivated or interested respondents, as assessed by the teachers, tend to prefer the teacher situation to the self-paced situations. Taking P-Two $> 1$ and P-Two $< -1$ as our categories, only increases $\chi^2$ slightly in this case, to about 8.5.

Both P-One and P-Two are thus quite meaningful variables. Combining the two sets of data we can predict that a respondent high on P-One and low on P-Two will have a strong tendency to prefer the lecture situation although he will also, of course, base his choice upon the method of instruction he actually received, reading age and other factors.

Figure 11-2 shows the relationship between P-One, P-Two and choice of teaching situation. The 43 respondents represented are those members of the microfiche and booklet-groups giving the teacher situation their first preference. About 50% of the respondents fall in the lower right quadrant, double the number expected on a non-associative basis, with $\chi^2 = 18.0$, significant to the 0.001 level.

Thus far we have analysed the responses to question 4 of the questionnaire. Once the respondents are given the choice of five teaching situations as in question 6 the response pattern changed considerably. Table 11-23 shows the composite data.
Fig. 11-2
Students from Fiche and Booklet Group preferring Lecture
**TABLE 11-24**

**FIRST PREFERENCE**

**TEACHING SITUATION**

<table>
<thead>
<tr>
<th>ALLOCATED GROUP</th>
<th>TEACHER</th>
<th>MICROFICHE</th>
<th>MICROFICHE + TEACHER</th>
<th>BOOKLETS</th>
<th>BOOKLETS + TEACHER</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEACHER</td>
<td>35</td>
<td>13</td>
<td>34</td>
<td>2</td>
<td>4</td>
<td>47.1</td>
</tr>
<tr>
<td>MICROFICHE</td>
<td>13</td>
<td>15</td>
<td>35</td>
<td>2</td>
<td>3</td>
<td>0.001</td>
</tr>
<tr>
<td>BOOKLETS</td>
<td>8</td>
<td>15</td>
<td>21</td>
<td>7</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>46</td>
<td>43</td>
<td>90</td>
<td>11</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>46</td>
<td>133</td>
<td></td>
<td>41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11.2 Woodville High School: Survey Results Contd.

(vi) Effects of P-Two Contd.

Now 58% ( = 133 x 100) of respondents gave one of the microfiche options their first preference, a considerable increase upon the 42% who did so when obliged to choose between only three situations (Table 11-13). But the percentage giving the teacher situation first preference has fallen from 43% to only 20% while the percentage preferring booklets has only increased slightly from 15% to about 18%.

Although $\chi^2 = 47.1$ is still highly significant for $(4 - 1) \times (3 - 1) = 8$ degrees of freedom it is less than the $\chi^2 = 97.3$ value obtained from Table 11-13 for $(3 - 1) \times (3 - 1) = 4$ degrees of freedom. This reflects a weakening of the "carry over" effect discussed previously with a considerable spill over from the teacher-group to those now giving the microfiche plus teacher "combined" option their first preference. However, the strong bias against booklets is still very much evident even with the inclusion of the booklet plus teacher option.

If the responses to question 6 are analysed there is no longer any evidence of a significant association between P-One or P-Two and choice of teaching situation. Tables 11-25 (a) and 11-25 (b) list the relevant data.

**TABLE 11-25 (a)**

FIRST PREFERENCE

TEACHING SITUATION

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>ONE OF MICROFICHE SITUATIONS</th>
<th>ONE OF BOOKLET SITUATIONS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-ONE &gt; MEAN</td>
<td>31</td>
<td>61</td>
<td>20</td>
<td>2.46</td>
</tr>
<tr>
<td>P-ONE &lt; MEAN</td>
<td>21</td>
<td>69</td>
<td>21</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>52</td>
<td>130</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

370


### TABLE 11-25 (b)

#### FIRST PREFERENCE

**TEACHING SITUATION**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEACHER</th>
<th>ONE OF MICROFICHE SITUATIONS</th>
<th>ONE OF BOOKLET SITUATIONS</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-TWO &gt; MEAN</td>
<td>22</td>
<td>65</td>
<td>22</td>
<td>1.53</td>
</tr>
<tr>
<td>P-TWO &lt; MEAN</td>
<td>31</td>
<td>66</td>
<td>19</td>
<td>(NS)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>53</td>
<td>131</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

The $\chi^2$ values of 2.46 and 1.53 are considerably lower than the values of 5.1 and 8.2 obtained with the three-situation analysis (Tables 11-19 (a) and 11-20 respectively).

Summarizing the results for the Woodville High School respondents we can say that they indicate an overall acceptance of microfiche as an instructional medium especially if a teacher is made available "to answer questions". On the other hand, they indicate an overall rejection of programmed-booklets for which even the "carry over" effect, the tendency of respondents to give booklets their first preference if they had been exposed to booklets during the experimental sessions, was not sufficient to surmount. The preference for microfiche is of course enhanced by its novelty but the data clearly shows its ready acceptance both by respondents who had worked with it and those who had not.
12. DISCUSSION OF EMPIRICAL RESULTS V: SURVEY DATA B

Students' and Teachers' Comments on Teaching Situations

In the last chapter we considered the preferential patterns of respondents. However the questionnaires distributed to the Kilkenny College of Further Education and Woodville High School students also asked them to specify whether they found the:

(1) microfiche viewers
(2) booklets
(3) lecture or lesson with the teacher easy or difficult. (For exact wording see Appendix 7).

The Woodville High School students were also asked whether they would like to see microfiche viewers available in the resource centre or open space unit of their school "for them to work on when they felt like it".

I Comments from Kilkenny College of Further Education Students

Comments are shown in Table 12-1. "PM" indicates "Preparatory Mathematics student" and "SOM" and "SOS" indicate "Stage 1 Mathematics" and "Stage 1 Science" respectively. "FPT" is the first preference of the respondent if an academic tutor is available (responses to question 8 grouped in just three categories with L indicating "lecture", M "microfiche" and B "booklets").

Not all respondents commented on the teaching situations but the comments from the 71 Stage 1 students and 34 Preparatory Mathematics students who did so are shown in Table 12-1.

The numbers (and percentages) of favourable and unfavourable responses from the two groups of respondents are shown in Tables 12-2 (a) and 12-2 (b) for each teaching situation. Some respondents gave both favourable and unfavourable responses to a given situation e.g. respondent 64 and 65 to microfiche.

Once again the response patterns are markedly different for the two groups of respondents. Stage 1 Mathematics and Science students are generally much more amenable to self-paced learning and far less deferential towards their lecturers than Preparatory Mathematics students.
### Table 12-1

**Comments on Teaching Situations**

<table>
<thead>
<tr>
<th>Respondent No</th>
<th>Microfiche EASY TO FOLLOW OR USE</th>
<th>Comments &amp; Reason</th>
<th>Booklets EASY TO FOLLOW OR USE</th>
<th>Comments &amp; Reason</th>
<th>Lecture EASY TO FOLLOW OR USE</th>
<th>Comments &amp; Reason</th>
<th>FPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (SOS)</td>
<td>Yes</td>
<td>&quot;Good in the fact that you can study at your own pace&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;OK, if the lecturer is easy to follow&quot;</td>
<td>L</td>
</tr>
<tr>
<td>2 (SOS)</td>
<td>Yes</td>
<td>&quot;Straightforward&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td>L</td>
</tr>
<tr>
<td>3 (SOS)</td>
<td>Yes</td>
<td>&quot;Easy to manipulate. Hard to take notes from in short time&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td>L</td>
</tr>
<tr>
<td>4 (SOS)</td>
<td>No</td>
<td>&quot;Under too much pressure i.e. time limit plus imminent test&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;Generally easy to follow but extremely difficult to catch up when lectures missed or beginning of individual lecture not completely understood&quot;</td>
<td>L</td>
</tr>
<tr>
<td>5 (SOS)</td>
<td>Yes</td>
<td>&quot;Simple operation once I learnt how to operate viewer&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;They were interesting and I had covered most of the work before&quot;</td>
<td>L</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
<td>BOOKLETS EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
<td>LECTURE EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
<td>FPT</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------</td>
<td>-------------------</td>
<td>---------------------------------</td>
<td>-------------------</td>
<td>-------------------------------</td>
<td>-------------------</td>
<td>-----</td>
</tr>
<tr>
<td>6 (SOS)</td>
<td>Yes</td>
<td>&quot;Clear and simple&quot;</td>
<td>Yes</td>
<td>&quot;Clear&quot;</td>
<td>Yes</td>
<td>&quot;Adequate lecturers&quot;</td>
<td>M</td>
</tr>
<tr>
<td>7 (SOS)</td>
<td>Yes</td>
<td>&quot;I can take it at my own pace&quot;</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>&quot;Too busy writing - no time to think about subject material&quot;</td>
<td>M</td>
</tr>
<tr>
<td>8 (SOS)</td>
<td>Yes</td>
<td>&quot;Facts were clear and concise in front of you&quot;</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>&quot;Lecturer is too quick with important work&quot;</td>
<td>M</td>
</tr>
<tr>
<td>9 (SOS)</td>
<td>Yes</td>
<td>&quot;Could go through it at my own pace&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td>10 (SOS)</td>
<td>Yes</td>
<td>&quot;Knew how&quot;</td>
<td>Yes</td>
<td>&quot;Same&quot;</td>
<td>-</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td>11 (SOS)</td>
<td>Yes</td>
<td>&quot;Because it was a well planned programme&quot;</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td>12 (SOS)</td>
<td>Yes</td>
<td>&quot;Well planned lesson easy to follow - instant 'replay'&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;Logically progressive - interesting&quot;</td>
<td>L</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE</td>
<td>BOOKLETS</td>
<td>LECTURE</td>
<td>FPT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>------------</td>
<td>-----------</td>
<td>---------</td>
<td>-----</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 (SOS)</td>
<td>No</td>
<td>&quot;Could not focus it&quot;</td>
<td>-</td>
<td>No</td>
<td>&quot;Same are too fast&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 (SOS)</td>
<td>Yes</td>
<td>&quot;Easy to use&quot;</td>
<td>Yes</td>
<td>&quot;Easy to use&quot;</td>
<td>No</td>
<td>&quot;Difficult to follow if you lose a point at any time - you just become confused&quot;</td>
<td></td>
</tr>
<tr>
<td>15 (SOS)</td>
<td>-</td>
<td>&quot;Did not like it&quot;</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 (SOS)</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>&quot;Not used to the system and can miss some work&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 (SOS)</td>
<td>Yes</td>
<td>&quot;Can go back over work covered&quot;</td>
<td>Yes</td>
<td>&quot;Can go back over work covered&quot;</td>
<td>No</td>
<td>&quot;Message is sometimes not put across well enough&quot;</td>
<td></td>
</tr>
<tr>
<td>18 (SOS)</td>
<td>No</td>
<td>&quot;Harsh on eyes&quot;</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 (SOS)</td>
<td>Yes</td>
<td>&quot;Simple operation can take time on hard bits - skimp over easy bits&quot;</td>
<td>-</td>
<td>No</td>
<td>&quot;Speed of delivery too fast&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 12-1 (CONT'D.)

COMMENTS ON TEACHING SITUATIONS (CONT'D.)

<table>
<thead>
<tr>
<th>RESPONDENT NO</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>LECTURE</th>
<th>FPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (50S)</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>&quot;But the actual picture was sometimes difficult to read&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 (50S)</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>&quot;Easy to follow, can go at own speed always able to go back over one's work&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 (50S)</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>&quot;Easy and straightforward but I would use it as an aid only, not as a teaching method&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 (50S)</td>
<td>Yes</td>
<td>-</td>
<td>No</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td></td>
<td>&quot;Progression is too quick to follow before it has been properly digested&quot;</td>
<td></td>
</tr>
<tr>
<td>24 (50S)</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>&quot;Operation fully understood and ease of learning maintained at a stable level&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE</td>
<td>BOOKLETS</td>
<td>LECTURE</td>
<td>FP1</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>----------</td>
<td>---------</td>
<td>-----</td>
</tr>
<tr>
<td>25 (SOS)</td>
<td>Yes</td>
<td>&quot;Simple operation and ability to work at one's own speed&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>26 (SOS)</td>
<td>No</td>
<td>&quot;Hard on the eyes&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>27 (SOS)</td>
<td>No</td>
<td>&quot;Poor focus&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>28 (SOS)</td>
<td>Yes</td>
<td>&quot;Easy to understand&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>29 (SOS)</td>
<td>Yes</td>
<td>&quot;it is simple and straightforward&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30 (SOS)</td>
<td>Yes</td>
<td>&quot;Can work in a logical order&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>31 (SOS)</td>
<td>No</td>
<td>&quot;Did not know how to pace myself&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32 (SOS)</td>
<td>Yes</td>
<td>&quot;Whatever you wanted to know was in front of you on the slides in easy-to-understand form&quot;</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE 12-1 (CONT'D.)

**COMMENTS ON TEACHING SITUATIONS (CONT'D.)**

<table>
<thead>
<tr>
<th>RESPONDENT NO</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
<th>LECTURE</th>
<th>FPT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
<td>EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
</tr>
<tr>
<td>33 (S0M)</td>
<td>Yes</td>
<td>&quot;Must first learn to use the viewer&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>34 (S0M)</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>35 (S0M)</td>
<td>Yes</td>
<td>&quot;Subject laid out in a logical sequence and questions could be checked to see where one has gone wrong&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>36 (S0M)</td>
<td>Yes</td>
<td>&quot;Simply explained and easy to follow&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>37 (S0M)</td>
<td>Yes</td>
<td>&quot;Instructions were very clear but noise in resource centre was distracting&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>38 (S0M)</td>
<td>Yes</td>
<td>&quot;Straightforward teaching aid&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE</td>
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<td>FPT</td>
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</tr>
<tr>
<td>30 (SOH)</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>&quot;Would be better if tutor was available to clarify small points&quot;</td>
<td></td>
<td>&quot;have done most before - just brushing up&quot;</td>
<td></td>
</tr>
<tr>
<td>40 (SOH)</td>
<td>Yes</td>
<td></td>
<td></td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>&quot;Easy&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41 (SOH)</td>
<td>Yes</td>
<td>&quot;Because you can take your time&quot;</td>
<td>Yes</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>&quot;Because you can take your time&quot;</td>
<td></td>
<td>&quot;Due to speed and method used&quot;</td>
<td></td>
</tr>
<tr>
<td>42 (SOH)</td>
<td>No</td>
<td></td>
<td>Yes</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>&quot;The only difficulty was the inaccuracy of the pointer - It indicated a square other than that actually shown&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43 (SOH)</td>
<td>Yes</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>&quot;Can go at one's own speed&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44 (SOH)</td>
<td>Yes</td>
<td></td>
<td></td>
<td>B</td>
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<tr>
<td></td>
<td>&quot;Self-explanatory&quot;</td>
<td></td>
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</tbody>
</table>
TABLE 12-1 (CONT'D.)
COMMENTS ON TEACHING SITUATIONS (CONT'D.)

<table>
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<th>RESPONDENT NO</th>
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<td>COMMENTS &amp; REASON</td>
</tr>
<tr>
<td>45 (SDM)</td>
<td>Yes</td>
<td>&quot;Had knowledge of work beforehand&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>46 (SDM)</td>
<td>Yes</td>
<td>&quot;Well set out with easy instructions&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>47 (SDM)</td>
<td>Yes</td>
<td>&quot;Simple to operate&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>48 (SDM)</td>
<td>Yes</td>
<td>&quot;Sufficient operations given for operation&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>49 (SDM)</td>
<td>Yes</td>
<td>&quot;Simple and change from usual system but would not like to see it used all the time&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50 (SDM)</td>
<td>Yes</td>
<td>&quot;Only problem encountered was when there was nobody to answer questions&quot;</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE 12-1 (CONT'D.)

**COMMENTS ON TEACHING SITUATIONS (CONT'D.)**

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<th>RESPONDENT NO</th>
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<td>EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
<td>EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
</tr>
<tr>
<td>51 (SOM)</td>
<td>Yes</td>
<td>&quot;Did not use&quot;</td>
<td>Yes</td>
<td>&quot;Very elementary - able to check answer and work back to find where errors were made&quot;</td>
</tr>
<tr>
<td>52 (SGM)</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>53 (SOM)</td>
<td>Yes</td>
<td>&quot;Presented information in an easy to follow manner&quot;</td>
<td>Yes</td>
<td>&quot;&quot;</td>
</tr>
<tr>
<td>54 (SOM)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>55 (SOM)</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
<td>Yes</td>
<td>&quot;Because you are able to refer back to any part of the book you did not understand&quot;</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE</td>
<td>EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
<td>BOOKLTS</td>
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</tr>
<tr>
<td>56 (SOM)</td>
<td>No</td>
<td>&quot;When more than one person involved it is difficult to keep pace&quot;</td>
<td>Yes</td>
<td>&quot;Easy working and good for looking back&quot;</td>
</tr>
<tr>
<td>57 (SOM)</td>
<td>Yes</td>
<td>&quot;Because you can move along at your own pace&quot;</td>
<td>Yes</td>
<td>&quot;Because you can move along at your own pace&quot;</td>
</tr>
<tr>
<td>58 (SOM)</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
<td>Yes</td>
<td>&quot;Easy subject matter, explanations were well laid out&quot;</td>
</tr>
<tr>
<td>59 (SOM)</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>60 (SOM)</td>
<td>Yes</td>
<td>&quot;Easy to follow with information at your fingertips&quot;</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
</tr>
<tr>
<td>61 (SOM)</td>
<td>Yes</td>
<td>&quot;It was all set up, everything was on the programme and was non-complex&quot;</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
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TABLE '2-1 (CONTD.)
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COMMENTS & REASON ,~OLLOW
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.~_J_R_U_)_E-+____

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(Si)r\)

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of algebra nCln-existent"

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<td>EASY TO FOLLOW OR USE</td>
<td>EASY TO FOLLOW OR USE</td>
</tr>
<tr>
<td>67 (SOM)</td>
<td>Yes</td>
<td>&quot;Layout was simple and progressed stage by stage through subject&quot;</td>
<td>No</td>
<td>&quot;Did not use&quot;</td>
</tr>
<tr>
<td>68 (SOM)</td>
<td>Yes</td>
<td>&quot;Explained the problems with ease but lacked somebody to answer questions&quot;</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>69 (SOM)</td>
<td>Yes</td>
<td>&quot;Lesson was easy to follow&quot;</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>70 (SOM)</td>
<td>No</td>
<td>&quot;I had never used the machine before and it took a while for me to get used to it&quot;</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>71 (SOM)</td>
<td>No</td>
<td>&quot;Some errors in programme; have to jump from frame to frame, cannot question machine&quot;</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE</td>
<td>BOOKLETS</td>
<td>LECTURE</td>
<td>FPT</td>
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<tr>
<td>(PM)</td>
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<td>EASY TO FOLLOW OR USE</td>
<td>EASY TO FOLLOW OR USE</td>
<td>COMMENTS &amp; REASON</td>
</tr>
<tr>
<td>72</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>73</td>
<td>Yes</td>
<td>&quot;Because method was easy&quot;</td>
<td>Yes</td>
<td>&quot;Could understand booklets&quot;</td>
</tr>
<tr>
<td>74</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>75</td>
<td>No</td>
<td>&quot;Printing too small - prolonged use causes bad eyesight&quot;</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
</tr>
<tr>
<td>76</td>
<td>Yes</td>
<td>&quot;Set out step by step&quot;</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>77</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>78</td>
<td>No</td>
<td>&quot;Difficult to use as misses proper explanation which only the teacher can give&quot;</td>
<td>Yes</td>
<td>&quot;Easy to use - better to assimilate and understand&quot;</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
<td>MICROFICHE</td>
<td>BOOKLETS</td>
<td>LECTURE</td>
<td>PPT</td>
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</tr>
<tr>
<td>79 (PM)</td>
<td>Yes</td>
<td>-</td>
<td>No</td>
<td>&quot;Sequence seems out of step&quot;</td>
</tr>
<tr>
<td>80 (PM)</td>
<td>Yes</td>
<td>&quot;Simple&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>81 (PM)</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>82 (PM)</td>
<td>Yes</td>
<td>&quot;Took some time to find out how the machine worked&quot;</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>83 (PM)</td>
<td>Yes</td>
<td>-</td>
<td>No</td>
<td>&quot;I don't like reading too much&quot;</td>
</tr>
<tr>
<td>84 (PM)</td>
<td>Yes</td>
<td>&quot;Easy to comprehend - could go back over difficult spots - good examples&quot;</td>
<td>-</td>
<td>&quot;Did not try&quot;</td>
</tr>
<tr>
<td>85 (PM)</td>
<td>Yes</td>
<td>&quot;Instructions were good and the instrument was easy to operate&quot;</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE 12-1 (CONT.)

**COMMENTS ON TEACHING SITUATIONS (CONT.)**

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<td>COMMENTS &amp; REASON</td>
</tr>
<tr>
<td>86 (PM)</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>&quot;My reading is not too good&quot;</td>
</tr>
<tr>
<td>87 (PM)</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
</tr>
<tr>
<td>88 (PM)</td>
<td>No</td>
<td>&quot;Couldn't keep my mind on the screen and absorb the facts&quot;</td>
<td>Yes</td>
<td>&quot;Prefer books&quot;</td>
</tr>
<tr>
<td>89 (PM)</td>
<td>Yes</td>
<td>&quot;The instructions were easy to follow&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>90 (PM)</td>
<td>No</td>
<td>&quot;Pages did not run in sequence&quot;</td>
<td>No</td>
<td>&quot;Pages did not run in sequence&quot;</td>
</tr>
<tr>
<td>91 (PM)</td>
<td>No</td>
<td>&quot;Not used to method - harder to recheck (go back)&quot;</td>
<td>Yes</td>
<td>&quot;Straightforward and easy to follow&quot;</td>
</tr>
<tr>
<td>92 (PM)</td>
<td>Yes</td>
<td>&quot;Without teacher, viewers were only a guide. If problems arise teacher is needed&quot;</td>
<td>Yes</td>
<td>&quot;But uninteresting - book didn't cover enough of the subject&quot;</td>
</tr>
<tr>
<td>RESPONDENT NO</td>
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<td>LECTURE</td>
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</tr>
<tr>
<td>93 (PM)</td>
<td>Yes and No</td>
<td>&quot;Easy if you know the problems. Otherwise vice versa&quot;</td>
<td>-</td>
<td>Yes and No</td>
</tr>
<tr>
<td>94 (PM)</td>
<td>-</td>
<td>&quot;Not used&quot;</td>
<td>No</td>
<td>&quot;Easy to learn but confusing&quot;</td>
</tr>
<tr>
<td>95 (PM)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>96 (PM)</td>
<td>No</td>
<td>&quot;You could not ask questions&quot;</td>
<td>No</td>
<td>&quot;You could not ask questions&quot;</td>
</tr>
<tr>
<td>97 (PM)</td>
<td>Yes</td>
<td>&quot;Student can stay on a frame until he understands it&quot;</td>
<td>Yes</td>
<td>&quot;Student can study a page until he understands it&quot;</td>
</tr>
<tr>
<td>98 (PM)</td>
<td>Yes</td>
<td>&quot;But boring and found mind was wondering&quot;</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>99 (PM)</td>
<td>Yes</td>
<td>&quot;I can understand programme&quot;</td>
<td>Yes</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE 12-1 (Contd.)

**COMMENTS ON TEACHING SITUATIONS (Contd.)**

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<th>BOOKLETS</th>
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<th>COMMENTS &amp; REASON</th>
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<th>COMMENTS &amp; REASON</th>
<th>FPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 (PM)</td>
<td>No</td>
<td>&quot;Because it brings you back to beginning of the study and you have to think harder&quot;</td>
<td>Yes</td>
<td>&quot;Because it shows you step by step&quot;</td>
<td>Yes</td>
<td>-</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>101 (PM)</td>
<td>-</td>
<td>&quot;Did not try&quot;</td>
<td>-</td>
<td>&quot;Did not use it&quot;</td>
<td>Yes</td>
<td>&quot;Because they explain what they mean&quot;</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>102 (PM)</td>
<td>-</td>
<td>&quot;Did not try&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;It was explained with easy methods&quot;</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103 (PM)</td>
<td>-</td>
<td>&quot;Did not try&quot;</td>
<td>Yes</td>
<td>&quot;Because it was set out in steps&quot;</td>
<td>Yes</td>
<td>&quot;Because they explained clearly and in steps&quot;</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104 (PM)</td>
<td>-</td>
<td>&quot;Did not use&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;Better teacher&quot;</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>105 (PM)</td>
<td>-</td>
<td>&quot;Did not try&quot;</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>&quot;Better teacher&quot;</td>
<td>L</td>
<td></td>
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</tbody>
</table>
12.1 Comments from Kilkenny College of Further Education Students Contd.

TABLE 12-2 (a)
NO. (AND %) OF FAVOURABLE AND UNFAVOURABLE RESPONSES – STAGE 1 STUDENTS
TEACHING SITUATION

<table>
<thead>
<tr>
<th>RESPONSE CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAVOURABLE</td>
<td>24</td>
<td>59</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(44%)</td>
<td>(72%)</td>
<td>(86%)</td>
</tr>
<tr>
<td>UNFAVOURABLE</td>
<td>31</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(56%)</td>
<td>(28%)</td>
<td>(14%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>55</td>
<td>82</td>
<td>14</td>
</tr>
</tbody>
</table>

TABLE 12-2 (b)
NO. (AND %) OF FAVOURABLE AND UNFAVOURABLE RESPONSES – PREPARATORY MATHEMATICS STUDENTS
TEACHING SITUATION

<table>
<thead>
<tr>
<th>RESPONSE CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAVOURABLE</td>
<td>24</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(80%)</td>
<td>(52%)</td>
<td>(60%)</td>
</tr>
<tr>
<td>UNFAVOURABLE</td>
<td>6</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>(20%)</td>
<td>(48%)</td>
<td>(40%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

Continued from page 373.

One reason is possibly because the Stage 1 respondents have a considerably higher educational level than the Preparatory Mathematics respondents, many of whom had been deemed of insufficient standard in Mathematics to commence the Stage 1 of the technicians course. Also the Preparatory Mathematics students were under considerable pressure to cover the course in one term and may have felt some resentment at having to participate in the experiment rather than "getting on with the job" with minimum delay. Another factor which may have influenced their responses was the fact that completed questionnaires were returned to the lecturers for
12.1 Comments from Kilkenny College of Further Education Students Contd.

handing onto the research team and not directly to the latter. Due to their rather vulnerable position as bridging course students they may have felt it unwise to be too critical of their lecturers. The Stage 1 students apparently had no such qualms.

It is interesting also to note that the respondents' choice of teaching situation, with an academic tutor available, is not always predictable from their comments given in Table 12-1. Some respondents were critical of the lecture situation and commented favourably upon microfiche self-paced learning but still gave the lecture their first preference; some criticised some aspects of microfiche self-paced learning but still gave it their first preference. The bulk of criticisms of microfiche evolved around its use as the sole mode of instruction as Table 12-3 indicates.

In Table 12-3 the unfavourable responses to microfiche are arranged in categories as follows:

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>REASON FOR RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>LACK OF TUTOR TO WHICH QUESTIONS COULD BE ADDRESSED</td>
</tr>
<tr>
<td>B</td>
<td>LACK OF CLARITY IN DESIGN OF PROGRAMMES</td>
</tr>
<tr>
<td>C</td>
<td>LACK OF MANUAL DEXTERITY IN HANDLING MACHINE</td>
</tr>
<tr>
<td>D</td>
<td>TIME LIMIT HAMPER CONCENTRATION I.E. SITUATION NOT REALLY &quot;SEF-PACED&quot;</td>
</tr>
<tr>
<td>E</td>
<td>VISUAL DIFFICULTIES - FOCUSING ETC.</td>
</tr>
<tr>
<td>F</td>
<td>LACK OF FAMILIARITY WITH METHOD. INABILITY TO SET ONE'S OWN PACE OR CONCENTRATE</td>
</tr>
<tr>
<td>G</td>
<td>OTHER</td>
</tr>
</tbody>
</table>

Thus about 25% of unfavourable responses evolved around the lack of a tutor to answer questions. If an academic tutor was made available this criticism would presumably disappear.

About 17% of unfavourable responses evolved around visual difficulties with focusing the microfiche viewers, problems which could be reduced
although students with serious visual problems would probably continue to have difficulties unless the size of the print was greatly increased, leading to a much greater number of frames in the programmes.

Even if these complaints and problems were rectified it would not necessarily lead to greatly enhanced acceptance of microfiche as an instructional medium. What is evident however, is that there is no one predominate cause of unpopularity with it and its acceptance or otherwise would seem to depend upon the overall situation in which it is used and the attributes of the individual students. A well-designed "debugged" programme given to students in a truly self-paced situation with an academic tutor available to answer questions would appear to be the most suitable arrangement for most students.

The criticisms of the lecture or teacher situations were much more consistent. In nearly every case the problem came down to one of pace - the student could not keep up with the lecturer because the subject matter was new to him, because he was too busy taking notes or because he had previously missed a lecture and fallen behind. A great number of respondents found the pace of the lecturers a real difficulty although, of course, many others were able to keep up with ease.
12.1 Comments from Kilkenny College of Further Education Students. Contd.

Another statistic worth considering is the number of respondents experiencing difficulty with one or more of the teaching situations, with or without stating a specific reason.

Table 12-4 shows the relevant data. No attempt was made here to analyze the cause of the difficulty or lack of difficulty. Also it should be remembered that each respondent could respond to all three teaching situations if he so wished.

**TABLE 12-4**

NO's (and %s) OF RESPONSES FINDING TEACHING SITUATION EASY OR DIFFICULT

<table>
<thead>
<tr>
<th>RESPONSE CATEGORY</th>
<th>LECTURE</th>
<th>MICROFICHE</th>
<th>BOOKLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;EASY&quot;</td>
<td>93</td>
<td>99</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>(74%)</td>
<td>(83%)</td>
<td>(83%)</td>
</tr>
<tr>
<td>&quot;DIFFICULT&quot;</td>
<td>33</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>(26%)</td>
<td>(18%)</td>
<td>(18%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>126</td>
<td>120</td>
<td>46</td>
</tr>
</tbody>
</table>

The table indicates that about one quarter of respondents who replied to this part of the questionnaire were experiencing difficulty with the lectures whereas about one fifth of those who had tried microfiche had experienced difficulty with it. Only a few respondents found difficulty with both the lecture and with microfiche however. Almost all found at least one of the teaching situations easy.

These data would seem to support the feasibility of a combination of teaching situations so that each student can select which situation best meets his requirements in a specific circumstance. Complete reliance upon the lecture situation is apparently disadvantageous to a significant percentage of the students surveyed.
12.2 Comments from Woodville High School Students

Woodville High School students who found their designated teaching method difficult were invited to comment on why they did so. The comments made are interesting and are reported in Table 12-5. "FP" is first preference or response to question 4. Some students also commented on the method they found easy.

**TABLE 12-5**
COMMENTS ON TEACHING SITUATIONS (WOODVILLE HIGH SCHOOL STUDENTS)

<table>
<thead>
<tr>
<th>RESPONDENT NO.</th>
<th>METHOD USED</th>
<th>EASY TO FOLLOW OR USE</th>
<th>COMMENT OR REASON</th>
<th>FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Percentages confuse me&quot;</td>
<td>T</td>
</tr>
<tr>
<td>2</td>
<td>Microfiche</td>
<td>Yes</td>
<td>&quot;It is easy&quot;</td>
<td>M</td>
</tr>
<tr>
<td>3</td>
<td>Booklets</td>
<td>No</td>
<td>&quot;Because you have to flip over&quot;</td>
<td>B</td>
</tr>
<tr>
<td>4</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;I did not understand percentages&quot;</td>
<td>M</td>
</tr>
<tr>
<td>5</td>
<td>Microfiche</td>
<td>Yes</td>
<td>&quot;Difficulty in understanding English in lecture&quot;</td>
<td>M</td>
</tr>
<tr>
<td>6</td>
<td>Booklet</td>
<td>No</td>
<td>&quot;Because it took too long to turn over the pages&quot;</td>
<td>M</td>
</tr>
<tr>
<td>7</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;I couldn't understand what it (the programme) was saying&quot;</td>
<td>T</td>
</tr>
<tr>
<td>8</td>
<td>Teacher</td>
<td>Yes</td>
<td>&quot;Because I'm still learning English I prefer teacher&quot;</td>
<td>T</td>
</tr>
<tr>
<td>9</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because the teacher explained it in a difficult way&quot;</td>
<td>M</td>
</tr>
<tr>
<td>10</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because everybody was talking and I didn't hear&quot;</td>
<td>T</td>
</tr>
<tr>
<td>11</td>
<td>Booklets</td>
<td>Yes</td>
<td>&quot;I found it easy to use&quot;</td>
<td>T</td>
</tr>
<tr>
<td>12</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;I couldn't understand it&quot;</td>
<td>T</td>
</tr>
<tr>
<td>13</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because half the time you didn't know what he was talking about&quot;</td>
<td>M</td>
</tr>
<tr>
<td>14</td>
<td>Teacher</td>
<td>Yes</td>
<td>&quot;Because before at the old school the teacher did not teach you maths properly&quot;</td>
<td>T</td>
</tr>
</tbody>
</table>
### TABLE 12-5

COMMENTS ON TEACHING SITUATIONS (WOODVILLE HIGH SCHOOL STUDENTS) CONT.

<table>
<thead>
<tr>
<th>RESPONDENT NO.</th>
<th>METHOD USED</th>
<th>EASY TO FOLLOW OR USE</th>
<th>COMMENT OR REASON</th>
<th>FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Booklets</td>
<td>Yes</td>
<td>&quot;Because the booklet was well expressed&quot;</td>
<td>B</td>
</tr>
<tr>
<td>16</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because I could not understand what he was teaching us&quot;</td>
<td>-</td>
</tr>
<tr>
<td>17</td>
<td>Booklets</td>
<td>No</td>
<td>&quot;Because it took too long to find a page&quot;</td>
<td>M</td>
</tr>
<tr>
<td>18</td>
<td>Teacher</td>
<td>Yes</td>
<td>&quot;I found it easy because the teacher could explain it more&quot;</td>
<td>T</td>
</tr>
<tr>
<td>19</td>
<td>Booklets</td>
<td>Yes</td>
<td>&quot;Easy&quot;</td>
<td>T</td>
</tr>
<tr>
<td>20</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because you are scared to ask things because you always get kept in&quot;</td>
<td>M</td>
</tr>
<tr>
<td>21</td>
<td>Booklets</td>
<td>No</td>
<td>&quot;Because you have to keep changing pages&quot;</td>
<td>M</td>
</tr>
<tr>
<td>22</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;Because if you lost your place you would have to start again&quot;</td>
<td>T</td>
</tr>
<tr>
<td>23</td>
<td>Teacher</td>
<td>Yes</td>
<td>&quot;It was more explained and much easier to follow&quot;</td>
<td>T</td>
</tr>
<tr>
<td>24</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because it was not explained enough&quot;</td>
<td>M</td>
</tr>
<tr>
<td>25</td>
<td>Booklets</td>
<td>Yes</td>
<td>&quot;I think books are easier because in the lesson sometimes the teacher doesn't teach you everything&quot;</td>
<td>B</td>
</tr>
<tr>
<td>26</td>
<td>Booklets</td>
<td>Yes</td>
<td>&quot;Easier because you didn't have to fiddle with buttons&quot;</td>
<td>B</td>
</tr>
<tr>
<td>27</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;Because there is too much fiddling about - have to keep changing frames etc.&quot;</td>
<td>T</td>
</tr>
<tr>
<td>28</td>
<td>Booklets</td>
<td>No</td>
<td>&quot;Because I had to change pages&quot;</td>
<td>T</td>
</tr>
<tr>
<td>29</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;Because I like it when teachers describe it step by step&quot;</td>
<td>T</td>
</tr>
<tr>
<td>30</td>
<td>Booklets</td>
<td>No</td>
<td>&quot;Because it doesn't explain as well as a teacher&quot;</td>
<td>T</td>
</tr>
</tbody>
</table>
TABLE 12-5 CONTD.

COMMENTS ON TEACHING SITUATIONS (WOODVILLE HIGH SCHOOL STUDENTS) CONTD.

<table>
<thead>
<tr>
<th>RESPONDENT NO.</th>
<th>METHOD USED</th>
<th>EASY TO FOLLOW OR USE</th>
<th>COMMENT OR REASON</th>
<th>FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Booklets</td>
<td>No</td>
<td>&quot;Because you had to go back and forward turning pages&quot;</td>
<td>B</td>
</tr>
<tr>
<td>32</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;Because it is too complicated&quot;</td>
<td>T</td>
</tr>
<tr>
<td>33</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;Because there was too much fiddling around and I like the teacher going over it step by step&quot;</td>
<td>T</td>
</tr>
<tr>
<td>34</td>
<td>Microfiche</td>
<td>No</td>
<td>&quot;Because you had to go backwards and forwards. I like it better step by step with the teacher&quot;</td>
<td>T</td>
</tr>
<tr>
<td>35</td>
<td>Microfiche</td>
<td>Yes</td>
<td>&quot;But I did not like it&quot;</td>
<td>T</td>
</tr>
<tr>
<td>36</td>
<td>Teacher</td>
<td>No</td>
<td>&quot;Because I could not understand the teacher&quot;</td>
<td>M</td>
</tr>
</tbody>
</table>

The above comments only represent the views of about 15% of a population of 230 or more. Thus they are probably not representative of the views of many or even of most students. Most comments came from students who had expressed some degree of difficulty with the teaching situation concerned (see Table 12-7 later). Nevertheless again we see that students may still give a method their first preference despite having experienced some difficulty with it e.g. respondents 10 and 31.

It must also be remembered that most of the respondents from the experimental groups had only received exposure to one self-paced situation and so were not in a position to compare them. Similarly respondents who had received instruction from a teacher during the experimental lessons had not been given an opportunity to try one of the self-paced situations and so were not in a position to make a comparison except on intuitive grounds.

Question 7 asked the students whether they would like to see microfiche viewers available in the resource centre or open space unit to work on when they felt like it. Table 12-6 (a), (b) and (c) summarizes the data upon the basis of sex of respondent, intelligence of respondent and first preference of teaching situation, for respondents answering this question.
### TABLE 12-6 (a)

**MICROFICHE VIEWERS IN RESOURCE CENTRE OR OPEN SPACE UNIT**

**VIEWS OF WOODVILLE HIGH SCHOOL STUDENTS**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>&quot;YES&quot;</th>
<th>&quot;NO&quot;</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOYS</td>
<td>107</td>
<td>24</td>
<td>-1.0  (NS)</td>
</tr>
<tr>
<td>GIRLS</td>
<td>71</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>178</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 12-6 (b)

**MICROFICHE VIEWERS IN RESOURCE CENTRE OR OPEN SPACE UNIT**

**VIEWS OF WOODVILLE HIGH SCHOOL STUDENTS**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>&quot;YES&quot;</th>
<th>&quot;NO&quot;</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ &gt; MEAN</td>
<td>85</td>
<td>25</td>
<td>-0.5  (NS)</td>
</tr>
<tr>
<td>IQ &lt; MEAN</td>
<td>90</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>175</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 12-6 (c)

**MICROFICHE VIEWERS IN RESOURCE CENTRE OR OPEN SPACE UNIT**

**VIEWS OF WOODVILLE HIGH SCHOOL STUDENTS**

<table>
<thead>
<tr>
<th>CATEGORY (FIRST PREFERENCE)</th>
<th>&quot;YES&quot;</th>
<th>&quot;NO&quot;</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEACHER</td>
<td>66</td>
<td>30</td>
<td>12.8  (0.005)</td>
</tr>
<tr>
<td>MICROFICHE</td>
<td>86</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>BOOKLETS</td>
<td>24</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>176</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>

338
12.2 Comments from Woodville High School Students Contd.

We see that boys and girls and bright and dull respondents are about just as likely to want to see microfiche viewers available in their schools. However students giving microfiche their first preference are much more likely to want to see viewers made available the percentage being about 90% from that category.

Even of the respondents not giving microfiche their first preference a sizeable percentage, about $90 \times 100 = 70\%$ would still like to see the viewers made available, presumably as a teaching aid or resource.

Overall about $176 \times 100 = 80\%$ of respondents would like microfiche viewers to be made available as a primary or secondary teaching resource.

Finally we can consider the number of respondents finding the various teaching situations easy or difficult. Unlike with the Kilkenny College of Further Education students most Woodville High School students only appraised the one teaching situation and so Table 12-7 only involves one response per student.

**Table 12-7**

<table>
<thead>
<tr>
<th>NO'S. (AND %S) OF RESPONSES FINDING TEACHING SITUATIONS EASY OR DIFFICULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESPONSE CATEGORY</td>
</tr>
<tr>
<td>&quot;EASY&quot;</td>
</tr>
<tr>
<td>&quot;DIFFICULT&quot;</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

The "difficult" responses were always accompanied by comments the full list of which were included in Table 12-5. Usually respondents who found their teaching situation easy felt no need to comment further. There is no tendency for the students to find any one method easier than any other. About 10% found the method difficult in each case.

* Possibly, in this case, in particular, many respondents may have given the response they perceived to be expected. Notwithstanding this, the positive response is very strong.
12.2 Comments from Woodville High School Students Contd.

The numbers experiencing difficulty with the various methods are too small to warrant further analysis.

.3 Comments from Teachers and Lecturers

Nineteen teachers or lecturers responded to the questionnaire reproduced in Appendix 7.3. Of these, 12 were from Kilkenny College of Further Education or elsewhere in the S.A. Department of Further Education, 3 were from Woodville High School and 4 from Klemzig Speech and Hearing Centre.

All teachers or lecturers had been personally involved with the use of microfiche and had cooperated with or participated in the research project.

Although the numbers are too small for a proper comparison we can, for convenience, classify the respondents thus:

CATEGORY A: Department of Further Education lecturers - concerned with post-secondary education and/or adult matriculation: teachers A-1 to A-12 inclusive.

CATEGORY B: Junior secondary mathematics teachers (all from Woodville High School): teachers B-1 to B-3 inclusive.

CATEGORY C: Remedial primary teachers (all from Klemzig Speech and Hearing Centre): teachers C-1 to C-4 inclusive.

Question 1 asked respondents whether they thought microfiche to be a valuable and viable instructional medium. Responses were as follows:

TABLE 12-8
RESPONSES TO QUESTION RE: VALUE AND VIABILITY OF MICROFICHE

<table>
<thead>
<tr>
<th>RESPONSE</th>
<th>&quot;YES&quot;</th>
<th>&quot;NO&quot;</th>
<th>DON'T KNOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATEGORY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>9</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

400
12.3 Comments from Teachers and Lecturers Contd.

Question 2 asked the respondent to indicate the specific applications he or she could envisage for microfiche in the School or College concerned. Three applications were specified:

(a) independent self-paced learning

(b) self-paced learning with a tutor or teacher present to answer questions

(c) as a "back up" resource with the teacher setting the pace through the programme

or/and

(d) other applications which the respondent might think of.

Table 12-9 (a) shows the response pattern for the 17 teachers and lecturers who answered this question. Two teachers specified both (b) and (c) and many teachers elaborated upon "other applications" or upon applications (a) to (c) in their specific situation.

**TABLE 12-9 (a)**

**APPLICATIONS OF MICROFICHE**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D (OTHER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

We see that few teachers were in favour of microfiche being used for independent self-paced learning. Most saw its use to be in conjunction with a teacher or tutor as or as a "back up" resource.

The "other" responses are shown in Table 12-9 (b) together with identification code i.e. of respondent.
**TABLE 12-9 (b)****

SUGGESTED APPLICATIONS FOR MICROFICHE OTHER THAN (a) TO (b) OR ADDITIONAL COMMENTS FROM TEACHERS OR LECTURERS

<table>
<thead>
<tr>
<th>I.C.</th>
<th>CHOICE MADE IF ANY</th>
<th>COMMENT ON ADDITIONAL APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>(b)</td>
<td>&quot;High capacity of information storage&quot;</td>
</tr>
<tr>
<td>A-2</td>
<td>(c)</td>
<td>&quot;Also as a catch up medium prior to taking courses where the entrance requirements are not quite met&quot;</td>
</tr>
<tr>
<td>A-3</td>
<td>(b)</td>
<td>&quot;Remedial Work. Also self-paced learning for those that were unable to attend college at specific times&quot;</td>
</tr>
<tr>
<td>A-4</td>
<td>(b)</td>
<td>&quot;As part of a self-paced learning system&quot;</td>
</tr>
<tr>
<td>A-5</td>
<td>(c)</td>
<td>&quot;Prefer (c), then (b), then (a)&quot;</td>
</tr>
<tr>
<td>A-6</td>
<td>(c)</td>
<td>&quot;I think it has value for all three. In (a) perhaps mostly as revision of previously learnt work, (b) has problems of scope i.e. is there a teacher who could answer all problems on all subjects!&quot;</td>
</tr>
<tr>
<td>A-7</td>
<td>(b)</td>
<td>&quot;Toss up between (b) and (c) - in practice it would depend on the appropriateness of the method to the teaching situation. (a) could offer independent learning by way of a change for the student&quot;</td>
</tr>
<tr>
<td>A-12</td>
<td>(b)</td>
<td>&quot;(b) and (c) represent an increased input for the student and are therefore preferable provided that other inputs are not reduced so as to make provision for microfiche&quot;</td>
</tr>
<tr>
<td>B-1</td>
<td>(c)</td>
<td>&quot;Possibly for revision in Years 11 and 12; or for remedial work in Junior School&quot;</td>
</tr>
<tr>
<td>C-1</td>
<td>(c)</td>
<td>&quot;I do not see (a) as a possibility for handicapped children and (b) only after thorough teaching of the subject&quot;</td>
</tr>
<tr>
<td>C-2</td>
<td>(c)</td>
<td>&quot;I feel it could be useful as a back up especially with deaf children who need continuous reinforcement&quot;</td>
</tr>
<tr>
<td>C-3</td>
<td>-</td>
<td>&quot;Unless a deaf child is very self-reliant and responsible this type of instruction is not a suitable medium for instruction with hard-of-hearing children but it has a slight possibility of being useful as a 'repeat' type lesson&quot;</td>
</tr>
</tbody>
</table>
12.3 Comments from Teachers and Lecturers Contd.

Question 4 asks the respondent whether he or she felt that microfiche viewers should be made available in the resource centre or open space unit of the School or College for students and teachers to use at their convenience for self-paced courses or for other purposes. The responses are shown in Table 12-10.

TABLE 12-10

MICROFICHE VIEWERS AVAILABLE IN R.C. OR O.S.U.

RESPONSE

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>&quot;YES&quot;</th>
<th>&quot;NO&quot;</th>
<th>CONDITIONAL &quot;YES&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>12</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

While the Further Education lecturers felt strongly that microfiche viewers should be made available with one exception from a respondent who expressed a view that "it should first be established as effective", the school teachers were more restrained. Possibly they felt that the students could not be relied upon to work at the machines at their own volition - the phrase "at their convenience" was probably too strong for them. Nevertheless overall 13 x 100 = 63% of respondents gave an unconditional "Yes" to this question.

Question 4 asked respondents whether, as teachers, they saw any serious problems arising from the use of microfiche as an instructional medium. If so what did they feel these problems to be. The following were received:

(1) some machines are difficult to load unless adequate instructions are given (respondent A-8)

(2) as a "product of our technological age" they could alienate the student (respondent A-8)
12.3 Comments from Teachers and Lecturers Contd.

(3) a tutor must be available to cope with student problems (respondent A-1)

(4) although microfiche might be accepted in the short term, for an extended course the "machine" nature of the viewers would put students off (respondent A-2)

(5) the vigorous "programmed" activity without any student freedom is restrictive (respondent A-2)

(6) student motivation - students do not gain comprehension of the subject as there is no interchange of ideas that take place in tutorials and lectures (respondent A-3)

(7) with the diazo negative images photographs cannot be displayed (respondent A-9)

(8) necessity of having a machine with a 240V power supply and tables and chairs (respondent A-9)

(9) technological problems such as difficulties with focussing, blown lamps, incorrect lenses, soiled machines etc. (respondent A-9)

(10) the problem of having to provide a reader to external students (respondent A-10)

(11) the necessity of having a sufficient supply of programmes to familiarize students fully with the method (respondent A-4)

(12) if a student cannot solve a problem he is directed to the correct answer without knowing where he went wrong (respondent A-5)

(13) the amount of time which must be devoted to preparing the material may make people reluctant to change it, even when change is desirable (respondent A-6)

(14) "no problems appear to me - it is in fact a good back-up medium to classroom teaching" (respondent A-11)

(15) the "band wagon" effect. There is nothing which microfiche can do which cannot be achieved with other media (books, slides, charts, O.H.P's etc.) Its value lies in its amenability to programmed self-paced materials and its cheapness and ease of storage and accessibility (respondent A-7)

(16) too costly (respondent B-2)

(17) time to prepare programmes unavailable (respondent B-2)

(18) retention of information (respondent B-1)

(19) cost (respondent B-1)

(20) preparation of programmes (respondent B-1)
12.3 Comments from Teachers and Lecturers Contd.

(21) selection of students who will benefit and the non-selection of others (respondent B-1)

(22) too costly - money is needed for other things (respondent B-3)

(23) harder to cover up errors of judgement than with a teacher (respondent B-3)

(24) deaf children require constant supervision and assistance. This is time consuming as teaching is virtually one-to-one (respondent C-1)

(25) "no" (respondent C-2)

(26) because of individual emotional as well as handicap problems, deaf children need mainly individual tuition. This type of equipment has only a limited use in our classroom situation.

These responses can be grouped under a number of headings, some under 2.

(a) instrumental - (1),(2),(4),(7),(8),(9),(10)

(b) need for tutor or teacher - (3),(6),(24),(26)

(c) social or sociological - (2),(15),(21)

(d) programme preparation or design - (10),(12),(13),(17),(20),(23)

(e) cost - (16),(19),(22)

(f) programmed learning per se - (5),(6),(18),(23)

This data is tabulated in Table 12-11

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>NUMBER</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>b</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>c</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>d</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>e</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>f</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>TOTAL</td>
<td>27</td>
<td>100</td>
</tr>
</tbody>
</table>
12.3 Comments from Teachers and Lecturers Contd.

Surprisingly most criticism evolved about instrumental and preparation difficulties and cost. Only 5% of responses involved the method per se.

It is informative to compare Table 12-11 with Table 12-3 gathered from Kilkenny College of Further Education students. There (12 + 17)% = 29% of students commented on instrumental difficulties, 23% on lack of a tutor or teacher and 14% on problems in programme design. Of course, problems of cost and preparation did not concern the students.

Question 5 asked teachers or lecturers to list what they saw to be the advantages of microfiche over other instructional media. Suggestions were as follows:

1. small size of microfiche facilitating its dispatch by mail provided recipient has a viewer (respondent A-12)
2. can cater for every able students but these would succeed regardless of the method (respondent A-8)
3. very flexible - student can use it when he wants to. But flexibility is limited as students don't have viewers at home (respondent A-2)
4. self-paced (respondent A-2)
5. self-paced (respondent A-3)
6. leads to more flexible time-table (respondent A-3)
7. simple to send microfiche by mail (respondent A-9)
8. cheap to reproduce diazo copies in quantity (respondent A-9)
9. copies can be easily discarded after use (respondent A-9)
10. cheapness and size combined with ease of storage (respondent A-10)
11. more suitable for branching programmes than most other media (respondent A-10)
12. self-paced (respondent A-4)
13. cheap and compact (respondent A-4)
14. self-paced (respondent A-5)
15. novelty - but this will not last (respondent A-6)
16. economy - once a master is available copies are very cheap (respondent A-6)
17. teacher doesn't have to be present (respondent A-11)
12.3 **Comments from Teachers and Lecturers** Contd.

(18) individualized instruction (respondent A-11)

(19) cheap and easy to store (respondent A-7)

(20) amenability to programmed self-paced materials (respondent A-7)

(21) can stimulate interest (respondent B-1)

(22) possibly can overcome weakness of particular teachers (respondent B-1)

Many of these "advantages" are not unique to microfiche but comments about cheapness of copies, ease of storage, cheap postage, compactness, ease of branching etc. certainly are. There seems to be confusion regarding "cheapness" and "cost" as several responses gave cost as a problem while others gave cheapness as an advantage. The difference lies in what some respondents perceive to be the cost of *programme* production and what others perceive to be the cheapness of microfiche *copy* production. This question is considered further in Appendix 1.
13. CONCLUSIONS

This research report has dealt with the feasibility and viability of the microfiche as a medium for self-instructional programmed-learning. In particular, the effectiveness of a number of self-paced programmes presented on this medium has been compared with that of conventional didactic teaching, but in addition, the effectiveness of the self-paced programmes presented on microfiche has been compared with that of precisely the same programmes presented in booklet form. In most cases the self-paced students using the programmes worked as individuals, but in some cases the performances of other students working in small groups were also investigated.

The statistical analyses of the empirical results obtained demonstrate that with the particular populations of students who participated in this investigation and with the given topics investigated, the self-paced programmes, whether on microfiche or in booklet form, were as effective in imparting information as the teachers and lecturers who co-operated in this research. This was the case with both the students who were above and below the mean I.Q. of given experimental populations.

Moreover, analyses of the responses of the students to surveys, presented in written questionnaire form, seeking their views on self-instructional programmed-learning show that for the majority of students, self-paced programmes presented on microfiche ranked about equal first preference with conventional teaching, provided an academic tutor is available to answer the queries of the self-paced students, whereas the programmes presented in booklet form ranked a poor third. With the programmes presented in booklet form some students complained of frustration in turning pages to and fro when following the branching programmes. However, with the microfiche, the criticisms were largely concerned with technical factors such as difficulty in focusing a microfiche viewer, and particular features of the content of a programme.

The preference of the students for the programmes presented on microfiche, compared with precisely the same programmes presented in booklet forms, lends support to the researchers' claim that the microfiche is a particularly suitable medium for self-instructional programmes. In addition, other advantages of the microfiche in this application
13. CONCLUSIONS Contd.

have been described, including suitability for branching programmes, low-cost and small bulk for storage or distribution by mail.

As is intended with self-paced programmes, it was found many students, the more able or those already familiar with the topics taught, gained considerable time savings in completing their programmes, compared with the fixed durations of the conventional didactic teaching situations. Conversely, the weaker students took longer and the survey data showed that many students complained that they were not able to keep up with the conventional lessons.

However, the facility offered by the self-paced programmes for the weaker sections of the experimental student populations to work at their pace, did not compensate, in this investigation, for their lower aptitudes as measured by intelligence tests. For it is clear that the more able students, as identified by these tests, not only finished the programmes more quickly but gained better results in the post-tests than the less able students. This lends support to those theories which suggest that the weaker students must first develop appropriate cognitive structures before they can assimilate new knowledge.

Given a longitudinal study in which the students are taught by a series of self-paced programmes, it is possible that within limits, the weaker students might develop appropriate cognitive structures and as a result, show a more significant improvement in the self-paced situation compared with conventional didactic teaching. This could constitute the basis for future research.

The results obtained indicate that self-instructional programmes presented on microfiche, both on educational grounds and on the more pragmatic grounds of, for example, cost and size, have considerable potential as a means to supplement or complement conventional didactic lessons. Further, the results indicate that these programmes may be an effective means of meeting the legitimate educational needs of those students who either for personal reasons, or owing to distance or shift-work, cannot or do not wish to attend normal courses of instruction. For example, such students with ready access to an educational institution could use its resource centre as a 'drop-in' study post. Conversely, those students who, owing to incaucacity or distance, cannot readily reach the institution, might be lent a microfiche viewer, and receive
13. **CONCLUSIONS Contd.**

their assignments in microfiche form by mail, in the same way that external correspondence students currently receive other materials but at lower cost.

To close, while the students who participated in this research had wide ranges of cognitive ability, personality attributes and ages, it is freely acknowledged by the authors that the scope of this report is somewhat limited because of its primary concentration on mathematical and mathematically based science/engineering subjects, and because only relatively short-term studies were involved. Bearing this in mind, we are particularly conscious that broad claims and generalisations based on this research may be dangerous and misleading.

However, what is claimed is that self-instructional programmed-learning using microfiche, namely the SIMPLE System, is a feasible instructional alternative, complement or supplement to, conventional didactic teaching, at least under certain conditions. It should, therefore, be seriously considered by teachers, educational technologists, librarians and others as a valuable addition to the repertoire of teaching methods currently available, and a method with very definite and distinctive advantages for them and their students.

R.J. Tod,  
E.R. Cawthron.  

September, 1977.
ACKNOWLEDGMENTS

1. Acknowledgment is made to Mr. L.A. Kloeden, Director-General of Further Education and Mr. M.H. Bone, the former Director-General of Further Education, S.A. Department of Further Education for their support for this project and permission to carry out this research at Kilkenny College of Further Education.

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5. Acknowledgment is made to Mr. R. Goldsworthy, former Principal of the Woodville High School for allowing research to take place in his School, to Mr. J. Riches, former Senior Maths Master at the Woodville High School, for his co-operation in this research and for assisting in programme design and testing, and to other staff who co-operated with the researchers.

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R.D. Portus, Lecturer, School of Electronic Engineering
S.C. Ratcliff, Lecturer, School of Electronic Engineering
B. Reader, Lecturer, School of Electronic Engineering
R.W. Temple, Lecturer, School of Electronic Engineering.

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Mr. B. Tyndale, Branch Manager, S.A. Branch, Computer Microfilming of Australia Pty. Ltd., Clovelly Park, S.A. 5042

Mr. B. Carrick, Managing Director, Latrobe Colourlab (Micropublishing Division), South Melbourne, Vic. 3205

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<table>
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</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

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APPENDICES

APPENDIX 1

Cost-Effectiveness Considerations

In this report it has been demonstrated that self-instructional programmed-learning using microfiche is effective. However, as John Annett has pointed out, it is quite another matter to demonstrate the cost-effectiveness of programmed-learning in a general way (140). Rather, the cost-effectiveness of programmed-learning compared with, for example, conventional didactic teaching depends very much upon the application and the environment in which it is used.

Obviously, with any form of programmed-learning, the greater the student population likely to use a given programme, the lower the per capita cost of the initial programme design and production costs spread over the student population. Thus, with a given programme and a given student population, one could compare the cost per student taught by a programme, with the cost per student taught by the didactic method, allowing for the salary of the teacher. The latter should also allow for the time taken by the teacher to prepare his lecture, and for the time he takes to give feedback to the students on their success or failure in formal tutorials or elsewhere, to the same extent as that designed into the given programme.

However, this approach is still an oversimplification of the situation, for it ignores the costs of the initial training of the teacher or for that matter of the programme designers. The question of just how far one pursues cost-effectiveness considerations will depend very much on the policy of the organisation seeking the comparison. For, in addition to the difficulties referred to above, one may or may not be obliged to include the overheads of the capital recurrent costs of the buildings, for example conventional classrooms, open-plan classrooms or resource centre, or the cost of the equipment used, in one's calculations.

What is more, the authors of this report do not advocate the use of self-instructional programmed-learning by students in isolation in all applications, for it has been demonstrated that the majority of students prefer the situation in which an academic tutor is available to answer their queries. Similarly, the authors regard programmed-learning as being complementary or supplementary to didactic teaching rather than as a complete alternative to it, except in special cases, for example with remote students, for whom this is largely un-
APPENDIX 1 Contd.

avoidable. If this philosophy is adopted, then the cost-effectiveness analyses become, depending on the degree of teacher involvement in the programmed-learning situation, even more specific and restricted to particular applications.

Further, perhaps the crucial factors are the personal advantages of given teaching methods to the students, and these are even more difficult to quantify. To take yet other examples, just how does one assess, at least in the short-term, with other considerations being equal, the value to a student of being able to study at his own pace and at a time that is convenient to him, that programmed-learning offers. Also, in a short-term study it is not possible to assess the improved quality of teaching that students may receive when didactic teaching is supplemented or complemented by self-paced programmed-learning. For the latter should not only directly provide carefully prepared teaching but by freeing the teacher from some aspects of his work, it should indirectly provide him with an opportunity to improve his professional skills, see Section 3.1. Perhaps in a long-term study it may be possible to investigate the success of students with this integrated method of instruction. Similarly, it is difficult but perhaps not impossible in every application to assess the effective cost of the time saving achieved by the more able students and by those already fully or partly familiar with given topics when self-paced programmed-learning is used.

Having deliberated on these difficulties, the authors of this report came to the conclusion that the most useful information that they could give in this appendix should comprise details of the average time taken by them to design and produce the self-instructional programmes used, the cost of the equipment required for the various means of producing self-instructional programmes on microfiche, and a comparison of the costs of the reproduction of programmes in microfiche and booklet forms. The prices quoted are those applicable to Australian Educational institutions.

With this information at hand the reader should, it is hoped, be in a position to estimate the costs, after making due allowance for institutional policy on overheads, to his establishment of producing self-instructional programmes in microfiche or booklet form. Further, for a given application it should be possible, within the constraints described above, to make an estimate of the respective costs of didactic teaching and programmed-learning. However, the
cost estimates supplied should be used with discretion as the micrographics and printing industries are subject to rapid advances and the prices quoted and the techniques described could conceivably be rapidly superseded. It is for this reason that this section which considers the vital question of cost effectiveness, is presented in the appendices rather than in the main body of the report.

Figure A1-1 is a simplified process flow chart showing the various processes described in Section 4 of this report and used by the researchers to produce self-paced programmes either in microfiche or booklet forms. The remaining subsections of this appendix deal with the times taken, and the equipment and materials costs involved in each of these processes.

1 Programme Design and Layout
As described in Section 4.1 of this report, the programmes used in this investigation were designed by the research team comprising the Chief Investigator, the Research Officer and the Illustrating Assistant in 3 or 4 hours, using the whiteboard to layout the frames of the programmes. In most cases, teaching staff with special expertise and interest in the programmes also participated in the programme design. Using this as a basis the reader should be able to estimate the labour costs to design and layout a programme in his own environment. The materials costs involved in this stage of the production of a programme, namely a fraction of a ream of A4-sized paper, are negligible.

It is not claimed, however, that the programmes designed by the research team are necessarily the best possible on each topic. Certainly, time did not permit the full development and validation of the programmes to a stage where for example, it could be expected that say 70% of the students would obtain 50% of the possible marks in a given test after instruction.

Rather, the programmes were designed to contain the same material as the didactic lectures with which they were compared, and were intended to be completed by the average student in about the same time. The latter was a necessary constraint owing to the other commitments of the experimental subjects who were real students, undertaking formal courses of instruction and not specially recruited or paid 'volunteers'.
FIG. A1-1  SIMPLIFIED PROCESS FLOW CHART
OF PROGRAMME DESIGN AND PRODUCTION METHODS FOR MONOCHROME MICROFICHE

Start

Self-paced materials required?

Programme design

Producer out work in-house?

Will headlines/phototypesetter be used for lettering?

Produce lettering  Produce illustrations

Will illustrations only with phototypesetter be required?

Fix to master sheets

Will microfilm be the medium?

Produce in-house?

Photocopy master sheets

Step and repeat camera?

Photograph title

Photograph master photocopies

Process microfiche master

Produce own duplicates from microfiche master?

Jacket loading?

Other methods

Will booklet be the medium?

Produce printing master

Print

Collate

Bind

End

End

Other media

To bureau

To bureau

No

No

No

No

No

No

No

No

No

No

No

No

No

No
1. Programme Design and Layout Contd.

Full development and validation of the programmes would undoubtedly considerably increase the development time and cost of the programmes.

2. Art Work

After the programmes had been designed and laid-out using the whiteboard, the Illustrating Assistant took about 35 hours to produce and assemble the lettering and illustrations for A4-sized masters of the average 60 frame programme using a Headliner to produce the lettering. As described in Section 4.2.1 this method is considerably more efficient than the former system which used an electric typewriter, stencils and Letraset. A 98 frame programme would take proportionately longer.

However, it may be confidently expected that the quality of the product and the time taken to produce it may be greatly improved by the use of a phototypesetter. Unfortunately, while they have seen a machine demonstrated, the investigators have no personal experience with the latter but as suggested in Section 4.2.1, a phototypesetter could be used for a range of institutional purposes, for example the production of prospectuses, brochures, etc., in addition to the preparation of self-instructional programmes, thus leading to greater economies.

a) Equipment Costs for Lettering

Below are listed the approximate costs of the equipment required for the suggested different methods of producing the lettering for the A4-sized masters of the programmes.

- Electric typewriter, supplied with two typing elements, approximately $843.00
- Additional typing elements $15.75 each
- Headliner with built-in automatic processor $3170.00
  Alternatively, the Headliner may be rented, including preventative maintenance (within an 8 km radius of a capital city GPO) for $166.00/month
- Typemasters (fonts) ordered with machine $65.00 each
  otherwise $86.00 each
- Phototypesetter (includes price of one type disc)
  5½ - 36 point letter size $17000.00
  5½ - 72 point letter size $20000.00
  Higher speed versions are available at greater cost.
  Alternatively, the phototypesetter may be leased from a finance company.
2 a) **Equipment Costs for Lettering Contd.**

Type discs (fonts) $ 550.00 each

Paper processor associated with phototypesetter $ 1250.00

Alternatively, the processor may be rented

(within an 8 km radius of a capital city GPO) for $ 69.00/month

b) **Materials and Labour Costs for Lettering**

Compared with the labour costs, the materials costs involved in producing the A4-sized masters of the self-instructional programmes are negligible. However, it is appreciated that in some establishments labour costs are hidden whereas materials costs are generally overt.

When the electric typewriter, stencilling and Letraset (or equivalent) method is used to produce the A4-sized masters, the materials cost will be greatly influenced by the amount of Letraset used. Similarly, with the Headliner, the amount of paper film used will be a function of both the amount of text used in the programme, and the size of the lettering used. The length of film used in a typical programme in this project was 30 m. At a cost specified as $15.10/100 ft. this represents a paper film cost of approximately $15.00 per 60 frame programme. To this, of course, should be added the cost of say 35 hours labour for the complete art work, plus any equipment or other overheads that may be relevant. For a 98 frame programme the cost will be proportionately greater. The cost of chemicals is normally in the region of $8.00 per month.

Conversely, the phototypesetter produces the required text directly on roll paper for which the cost is specified as $39.00 per 150 feet of 8 inch wide paper. Consequently, the requisite lettering on A4-sized sheets, has a materials cost of approximately 26¢/sheet. Thus for a 60 frame programme the materials cost of the A4-sized masters is about $16.00, and for a greater number of frames the cost is proportionately greater. The cost of chemicals is normally in the region of $30.00 per month.

The chemical costs for the Headliner and for the phototypesetter given above are based on an average usage and on the basis that the chemicals are generally changed weekly.

3 **Monochrome Microphotography**

As described in Section 4, the researchers in this investigation initially used 16 mm microfilm and microjackets to produce the early
A.1.3 Monochrome Microphotography Contd.

microfiche masters used in this investigation. However, this method was later rendered obsolescent by the acquisition of a step and repeat camera/processor, which not only reduces the materials and labour costs but produces a better product. Alternatively, small scale programme designers may find it more economic to have a commercial micrographics bureau produce their microfiche masters, and if necessary also prepare their A4-sized masters from sketches, rather than investing in specialised equipment or employing specialised staff. The respective costs of these three approaches are outlined below.

1 Photocopy A4-sized Masters

As described in Section 4.2.2, the microfilm camera tends to reproduce the shadows around the edges of any illustrations or lettering, produced separately and then glued onto the A4-sized master sheets. Similarly, it reproduces any shadows thrown by white opaque fluorescent fluid when this is used to mask any errors. However, these difficulties may be overcome if the master sheets are first photocopied by a photocopier which is not sensitive to the shadows, and then the photocopies are used as the A4-sized masters.

Consequently, when the Headliner is used to produce the lettering, all the A4-sized sheets used must be photocopied before microphotography. Similarly, when typing or the phototypesetter is used, at least those sheets bearing glued-on illustrations should be photocopied, plus any suspect sheets to which corrections have been made.

Since typical photocopying costs are in the range of 3 to 5c/sheet, the materials cost of, for example, 60 photocopies will be in the range of $1.80 to $3.00. To this should be added the cost of say 30 minutes labour and any equipment or other overheads that may be relevant.

2 The Monochrome Microfiche Master using the Microjacket

a) Equipment Costs

The equipment required to produce the microfiche microjacket master is listed below.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microfilm planetary camera, approximately</td>
<td>$1600.00</td>
</tr>
<tr>
<td>Microfilm jacket loader, approximately</td>
<td>$1100.00</td>
</tr>
<tr>
<td>(not absolutely essential but very desirable)</td>
<td></td>
</tr>
</tbody>
</table>
A.1.3.2 b) **Materials and Labour Costs**

To determine the cost of the master microjacket it is first necessary to determine the cost of processed film per frame.

16 mm monochrome film in 100 feet rolls costs $4.60/roll

Commercial processing costs $2.70/roll

$ 7.30/roll

100 feet of film carries approximately 2500 images, therefore the cost per image is approximately $0.29/roll

Hence for a 60 frame programme the cost of processed film is 17.5¢

The cost of the microjacket is approximately 10.0¢

Therefore the total materials cost of the loaded microfiche jacket master is approximately 27.5¢ each

However, the above cost which includes commercial processing labour costs, excludes the labour costs of the local microphotography, jacket loading and the cost of despatch and collection of the exposed film.

As a guide to the reader it is estimated that the microphotography and jacket loading for one roll of film, will take an operator approximately 5 hours. Therefore, with a given operator the labour costs per jacket may be readily estimated, and to this should be added the labour and other costs involved in the despatch and collection of the film to and from the processor.

3 **The Monochrome Microfiche Master using the Step and Repeat Camera**

a) **Equipment Costs**

Two approaches are possible, namely the step and repeat camera/processor as used by the authors of this report or a step and repeat planetary camera without processor. The former has the advantage that it produces a finished microfiche master within 90 seconds of the last exposure but the disadvantage of a fixed focal length and reduction ratio, and consequently it can handle
A.1.3.3 a) **Equipment Costs Contd.**

originals of one size only, for example A4-size. The step and repeat planetary camera has the advantage of variable focal length and reduction ratios and hence it is more flexible, but it requires a developing unit, without which the exposed film must be sent to a commercial film processor. The approximate costs of these equipment alternatives are given below.

- **Microfilm Step and Repeat Camera/Processor**, depending on format, approximately $14000.00 to $15000.00
- Alternatively, this may be rented at about $750.00/month

or

- **Microfilm Step and Repeat Planetary Camera**, approximately $17000.00
- and requisite Developing Unit, approximately $4500.00

However, for small numbers, the master fiche may be developed in the conventional photographic trays in the normal way.

b) **Materials and Labour Costs**

The researchers have no experience with the microfilm step and repeat planetary camera. Therefore the figures below refer only to the step and repeat camera/processor used in this investigation.

- **Unexposed sheet film 105 x 149 mm for the microfiche master**
  - 91.6 c each
- **Approximate cost of processing chemicals**
  - 7.0 c
- **Total cost, excluding labour, for the microfiche master**
  - 98.6 c each

This material cost is of course constant irrespective of whether or not the whole 98 frame potential of the fiche is utilized. This cost at first sight appears unfavourable compared with the microfiche master. However, the labour costs involved in jacket loading and in the despatch and collection of the exposed film are eliminated, and as a result in most applications the step and repeat camera/processor product will be less expensive overall.

Moreover, perhaps even more relevant is that the step and repeat camera/processor produces a better product with minimal delay, plus the added advantages that new equipment or operator mal-
A.1.3.3 b) **Materials and Labour Costs Contd.**

functions are quickly detected, and the exposed film is not subject to the risk of loss or damage while being transported to and from processing.

c) **Commercial Bureau Production of the Monochrome Microfiche Master**

Commercial microphotographic bureau services are available which will produce a microfiche master from original documents prepared by the client or alternatively will produce the masters of each frame, including typesetting, art work and layout from rough drafts. The approximate costs of these services are given below.

Camera ready programme requiring microfilming only, approximate cost $ 15.00

Programme requiring typesetting, art work, layout and microfilming, cost for example of a given 67 frame programme.. $1500.00

However, this cost which is subject to the content and complexity of each frame is merely illustrative.

.4 **Monochrome Microfiche Duplicates**

Again two approaches are possible, one may purchase equipment and employ staff to produce one's own microfiche duplicates, or one may have the duplicates commercially produced by a micrographics bureau.

a) **Diazo Duplicates - Produced In-house**

To produce diazo duplicates from the microfiche masters in one's own institution the following costs are relevant.

i) **Equipment Costs**

The cost of a microfiche diazo duplicator ranges in price from approximately $2100 to $3500 depending on the speed of reproduction required. The respective speeds of reproduction range from about 200 duplicates/hour to 700 duplicates/hour.

ii) **Materials and Labour Costs**

The cost of the diazo filmsheet for the diazo duplicates is approximately 5¢/fiche. The cost of the ammonia processing chemical is negligible per fiche.
A.1.3.4 a) ii) Materials and Labour Costs Contd.

The cost of labour per duplicate is a function of the operator's salary and the rate at which he is employed in producing duplicates and will vary from institution to institution.

b) Diazo Duplicates - Produced by a Commercial Bureau

From commercial micrographics bureaux, the researchers have received quotations of 12-18c/diazo duplicate.

c) Vesicular Duplicates - Produced In-house

To produce vesicular duplicates (preferred when photographs are to be reproduced, see Section 4.3.3) in one's own institution the following costs are relevant.

i) Equipment Costs

Vesicular Printer, approximately $ 950.00
Vesicular Developer, approximately $ 500.00

The maximum speed of reproduction is approximately 150 maximum duplicates/hour.

ii) Materials and Labour Costs

The cost of the vesicular film sheet for the vesicular duplicates is approximately 10c/fiche. No chemicals are required for processing. Again the labour costs per duplicate involved are a function of the operator's salary and the rate at which he is employed in producing duplicates.

d) Vesicular Duplicates - Produced by a Commercial Bureau

From a commercial micrographics bureau, the researchers have received a quotation of 16c/vesicular duplicate.

4 Colour Microphotography

As described in Section 4.4, the researchers have only limited experience with colour microphotography. However, since the research experimentation was completed, colour microfiche masters and colour duplicates have become available from at least one Australian micrographics bureau. The microfiche masters may be produced from printed matter, photographic prints or slide transparencies.
A.1.4 Colour Microphotography Contd.

A quotation received from a commercial bureau gave the following prices.

Production of a 98 frame colour microfiche master  $ 95.00 each

Production of colour duplicates:

- $ 70.00/10 copies
- $125.00/25 copies
- $225.00/50 copies
- $350.00/100 copies

It is expected that these prices may decrease as the volume of colour microphotography increases.

5 Microfiche Viewers

The current cost of microfiche viewers or readers, the terms are interchangeable, equipped with suitable index cards and image selection pointers is currently approximately $200 each.

A guide to the selection of microfiche viewers has been published elsewhere (141). Briefly microfiche viewers are available with two main types of optical systems. These are 'rear projection' types in which the light bearing the magnified microfiche image is projected onto the rear of a translucent screen for viewing, and the 'front projection' types in which the light is projected onto the front of a mirror surface screen for direct viewing. With the latter the screen is at approximately the same level as the surface bearing the microfiche viewer, and the screen may generally be tilted for convenience. Some users argue that as a result, the front projection screens are less tiring to use for long periods than the nearly vertical screens of most rear projection readers. However, there appears to be no consensus on this. Similarly, there is no agreement on the best colour tint of the screen material of rear projection screens when colour microfiche are used. With the front projection screens this problem does not generally arise as non-tinted mirrors are normally used.

The screen shape selected will be determined by the microfiche formats likely to be used. Obviously, for self-instructional programmes it is important that the viewer is able to display the complete page of a frame, otherwise the programme designer's carefully constructed presentation will be undermined. Similar constraints apply to the choice of optical magnification. The most common microfiche reduction ratios are 20 x, 24 x, 42 x and 48 x, and satisfactory reproduction is generally possible when 20 x or 24 x fiche are viewed with 24 x or 20 x optical...
A.1.5 Microfiche Viewers Contd.

systems, respectively. A similar reciprocity exists between 42 x and 48 x systems. In this research, advantage was taken of this flexibility, as those duplicates produced from microjacket masters had 20 x reduction, whereas those later produced by the step and repeat camera/processor had 24 x reduction. The microfiche viewers used had 24 x magnification.

Other important criteria in the selection of a microfiche viewer include size, weight and portability. These factors will be of greater or less significance, depending upon the application.

The number of microfiche viewers required in, for example a library-resource centre, will of course depend on the number of students simultaneously seeking access to microfiche programmes or reference materials, and whether they work as individuals or in groups. However, the number of viewers required can be reduced if peak demands are minimised by the introduction of scheduling procedures in which given categories of students have access to the readers at given times, or by requiring students to book access to the readers in advance. Obviously, these procedures should not be such that students are deterred and no doubt with greater experience, rules of thumb may emerge which predict the number of microfiche readers required in given applications.

Where the microfiche is used as a medium to store reference materials, it may be necessary to provide a microfiche reader/printer to reproduce hardcopy documents from microfiche frames. However, this should not generally be the case with self-instructional programmes, from which the students are normally expected to make their own notes.

The cost of a suitable reader/printer which can reproduce either diazo or vesicular duplicates (this necessitates changing the chemical toner used) is approximately $1372.00

The cost of A4-sized hard copies produced by this machine is approximately 4.5¢ each

6 Booklets
As described earlier in this report, for some groups of subjects, programmes were produced in both microfiche and booklet forms.
A.1.6 Booklets Contd.

With the latter the monochrome programmes were reproduced directly from the A4-sized masters, onto A4 bond paper using the offset printing process, and were bound with thin card covers, see Section 4.6.

a) Booklets - Produced In-house

For a 98 frame programme, the approximate materials cost, excluding labour, for single sided page offset printing is:

- $17.50 / 10
- $26.00 / 50
- $40.00 / 100
- $320.00 / 1000

This includes the cost of the paper photographic plates used to produce the offset printing masters. The costs of programmes with fewer frames would be nearly proportionately less. Conversely, the cost of colour plates will considerably increase the above costs.

b) Booklets - Produced Commercially

In order to provide fuller information on the true cost, including labour, of producing self-instructional programmes, the authors obtained the following quotations for a monochrome 98 frame programme, with single sided page printing and thin card covers, from a commercial offset printing house.

For quantities of 100, price $2.90 each
For quantities of 500, price $2.70 each
For quantities of 1000, price $2.35 each.

The above prices clearly demonstrate the cost advantages of the microfiche duplicates compared with booklets. As described in Section 3.1 the former have many other advantages as a medium for self-instructional programmed-learning.
Appendix 2

Reliability of scales used:

1. Personality Scales

To obtain the personality measures, P-One and P-Two, for the Woodville High School students, three teachers independently rated each student in a class on two 5 point scales -2, -1, 0, +1, +2. The ratings of each teacher were then converted to normal scores for each student in the usual manner using the overall data for the teacher and class under consideration. The normal scores were then averaged over the three teachers and the resultant "mean normal score" or Z value taken as a measure of the appropriate personality measure $\bar{Z} = \frac{1}{N_T} \Sigma Z_i$, where $N_T$ is the number of teachers per student.

$$\bar{Z} = \frac{Z_1 + Z_2 + Z_3}{3} \quad \text{(A.2.1)}$$

for each student where $Z_1$, $Z_2$ and $Z_3$ are the normal scores for the three teachers.

It was earlier seen that the values for P-One and P-Two did behave as quite reasonable independent or attributive variables and could be used to predict a student's attitude to the various teaching situations or and to account for a significant amount of variance in the dependent variable analysed even after the effects of the main test covariate, intelligence and mathematical aptitude have been taken into account.

Attempts to create variables by a "subjective process" is of course laden with difficulties. It is essential that the $Z$ values do have some predictive and analytic meaning and do behave as "real variables" whatever the difficulty in trying to relate them precisely to standardized objective tests, for example. For the Woodville High School students the P-One and P-Two measures did meet these criteria and there was a high degree of agreement amongst the teachers as to what the terms "extroversion-introversion" and "interest and motivation" meant to as teachers.

On the other hand, attempts to define P-One and P-Two measures for Kilkenny College of Further Education students failed because the correlations between the individual $Z_i$ values were too small to define a meaningful $\bar{Z}$ (equation A.2.1). The teacher-student contact was too sparse or short-termed to allow any consensus to emerge.
A.2.1 Personality Scales Contd.

In order to establish the usefulness of the P-One and P-Two scores a statistical procedure is available apart from the purely "try it and see" approach. The procedure consists of calculating the reliability of the scores reliability referring "to the consistency of scores obtained by the same persons when re-examined with the same test on different occasions, or with different sets of equivalent items, or under other variable examining conditions." (142)

The reliability or reliability coefficient \( \alpha \) is a measure of the amount of "signal" or explained variance in a score, "explained" meaning that fraction of variance which can be attributed to the students. If \( \alpha \) is small then much of the variance is due to the teachers or the immediate situation or other residual effects and so the \( Z_i \) values will differ markedly from teacher to teacher.

Cronbach gives a useful measure for \( \alpha_3 \) where the subscript "3" refers to the three teachers involved with each student. (143)

\[
\alpha_3 = \frac{3}{2} \left( 1 - \frac{3}{\Sigma} \text{variance in } Z_i \right) \left( \frac{1}{\text{variance in } \bar{Z}} \right)
\]  

(A.2.2)

As \( Z_i \) are standard scores, the numerator in the R.H.S. expression within the brackets is simply 3. Raw scores of course could also be used in (A.2.2).

The correlation coefficients between any two sets of standard scores \( Z_1, Z_2 \) and \( Z_3 \) for a class is also obtainable directly from the scores by

\[
\rho_{ij} = \Sigma Z_i Z_j \quad \text{N=1}
\]

(A.2.3)

where \( N \) is the number of students in the class.

Fortunately a computer sub-programme SPSS RELIABILITY is available which will calculate \( \alpha_3 \) and the \( \rho_{ij} \) values for each class directly from the raw scores. Table A-2-1 lists the results for 8 computer runs, one on each class of subjects. There were 250 subjects with personality data available.
TABLE A-2-1

RELIABILITY DATA

(1) P-ONE

<table>
<thead>
<tr>
<th>CLASS</th>
<th>( r ) VALUES</th>
<th>AVERAGE ( r )</th>
<th>( \alpha )</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.55, 0.50, 0.57</td>
<td>0.54</td>
<td>0.78</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>0.43, 0.70, 0.75</td>
<td>0.63</td>
<td>0.84</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>0.58, 0.59, 0.81</td>
<td>0.66</td>
<td>0.85</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>0.52, 0.36, 0.61</td>
<td>0.50</td>
<td>0.72</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>0.65, 0.67, 0.63</td>
<td>0.65</td>
<td>0.85</td>
<td>35</td>
</tr>
<tr>
<td>6</td>
<td>0.29, 0.23, 0.81</td>
<td>0.44</td>
<td>0.73</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>0.61, 0.56, 0.62</td>
<td>0.60</td>
<td>0.81</td>
<td>28</td>
</tr>
<tr>
<td>8</td>
<td>0.20, 0.42, 0.51</td>
<td>0.38</td>
<td>0.64</td>
<td>29</td>
</tr>
</tbody>
</table>

MEAN 0.55 0.78 31.3
S.D. 0.10 0.08 4.2

(2) P-TWO

<table>
<thead>
<tr>
<th>CLASS</th>
<th>( r ) VALUES</th>
<th>AVERAGE ( r )</th>
<th>( \alpha )</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.56, 0.56, 0.41</td>
<td>0.51</td>
<td>0.76</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>0.65, 0.67, 0.44</td>
<td>0.59</td>
<td>0.80</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>0.57, 0.78, 0.71</td>
<td>0.69</td>
<td>0.84</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>0.60, 0.54, 0.72</td>
<td>0.62</td>
<td>0.81</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>0.59, 0.59, 0.56</td>
<td>0.58</td>
<td>0.80</td>
<td>35</td>
</tr>
<tr>
<td>6</td>
<td>0.60, 0.66, 0.81</td>
<td>0.69</td>
<td>0.87</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>0.65, 0.73, 0.64</td>
<td>0.67</td>
<td>0.84</td>
<td>28</td>
</tr>
<tr>
<td>8</td>
<td>0.50, 0.59, 0.67</td>
<td>0.59</td>
<td>0.80</td>
<td>29</td>
</tr>
</tbody>
</table>

MEAN 0.62 0.82 31.3
S.D. 0.06 0.04 4.2
Personality Scales Contd.

The reasonably high overall values of \( \alpha \), about 0.8, indicate that the researchers are justified in treating P-One and P-Two as legitimate variables in the statistical analyses. P-One seems to be slightly less reliable than P-Two mainly due to lower values of average \( r \) and \( \alpha \) for classes 6 and 8. Although the researchers did not investigate the matter further it was possible that the teachers were relatively new to those classes and found P-One more difficult to estimate than the teachers for other classes.

Other Scales

Measuring the reliabilities of "objective tests" by direct application of formula (A.2.2) is difficult, as the variable to consider is no longer the teacher but the student who may perform differently at the same tests under differing situations, so his actual score is influenced by one or more extraneous sources of variance.

In practice it is often impossible to administer identical tests to students at different times in order to obtain a value of \( \alpha \), as the students' biographies will invariably differ between the successive administrations. What can be done is to consider a single application of the test under consideration as consisting of a number of sub-tests and then take the value of \( \alpha \) as a measure of internal consistency of the test.

Thus if we divide the test into just two equal parts with the even and odd items scored separately we can write:

\[
\alpha_2 = 2 \left( 1 - \frac{\text{variance in odd items}}{\text{variance in total scores}} \right) \left( 1 - \frac{\text{variance in even items}}{\text{variance in total scores}} \right)
\]

\[\text{A good approximation to } \alpha_2 \text{ is given by the Spearman-Brown formula:}\]

\[
\alpha_{SB} = \frac{2r}{1 + r}
\]

where \( r \) is the correlation between the even and odd scores.

To check the internal consistency of the test scores for the topic "Percentages": a representative set of 111 scores from Post-test 2 were...
A.2.2 Other Scales Contd.

analysed using the SPSS RELIABILITY sub-programme. The correlation $r$ was found to be 0.61 and $\alpha_{SB} = 0.76$. Similarly with the Post-test 1 scores for the topic "Simultaneous Equations" $r = 0.66$ and $\alpha_{SB} = 0.79$.

For the Stage 1 Science scores the splitting into even and odd items was not appropriate as the even and odd portions were not exactly equivalent in mark structure; rather the test was split into two halves each with equivalent mark structures. Table A-2-2 summarizes the computer output data where $r$ is the correlation between the two halves.

TABLE A-2-2

RELIABILITY DATA FOR STAGE 1 SCIENCE TEST SCORES

<table>
<thead>
<tr>
<th></th>
<th>Inductive Reactance</th>
<th>Capacitive Reactance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>POST-TEST 1</td>
<td>POST-TEST 2</td>
</tr>
<tr>
<td>$r$</td>
<td>0.72</td>
<td>0.87</td>
</tr>
<tr>
<td>$\alpha_{SB}$</td>
<td>0.84</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Owing to the time involved reliability coefficients could not be computed for all tests used in the research project but the representative data presented suggests a high degree of internal consistency in the test scores which were examined.

The item analysis discussions in the main test (Sections 8.4, 9.6 and 10.11) indicated that there were considerable differences in difficulty between items. Thus the values of $r$ and $\alpha_{SB}$ will depend on the internal structure of the tests. If for example, all even items happen to be easy and the odd items difficult, $r$ and $\alpha_{SB}$ would probably be quite small. If all items happen to be very easy, $r$ and $\alpha_{SB}$ would tend to be high. Thus the exact values of $r$ and $\alpha_{SB}$ are only representative values which could be changed by a re-ordering of the test items.
APPENDIX 3

Further Analysis of Questionnaire Data

The reader would have noticed that the statistical methods used in the discussions of the survey data - Sections 11 and 12 - were considerably simpler than those used in the analysis of the test results in Chapters 8 to 10. The analysis of the survey data involved simple non-parametric statistics, whereas the analysis of the test results employed parametric methods in order to sort out the variance contributions of several independent variables to the dependent variable under consideration.

More elaborate methods are of course available to analyse survey data especially if one is faced with the problem of disentangling several factors which may collectively determine a respondent's answer to a given question. One may also wish to collect all relevant results together in one table.

For example, consider the questionnaire given to the Woodville High School students (Appendix 7). One may define, say, 23 dichotomous variables V1 to V23 where:

\[
V1 = \begin{cases} 
0 & \text{if IQ of respondent is} < \text{Mean} \\
1 & \text{is} \geq \text{Mean}
\end{cases}
\]

\[
V2 = \begin{cases} 
0 & \text{if respondent is female} \\
1 & \text{male}
\end{cases}
\]

\[
V3 = \begin{cases} 
0 & \text{if respondent was not allocated to teacher situation} \\
1 & \text{was allocated to teacher situation}
\end{cases}
\]

\[
V4 = \begin{cases} 
0 & \text{if respondent was not allocated to microfiche situation} \\
1 & \text{was allocated to microfiche situation}
\end{cases}
\]

\[
V5 = \begin{cases} 
0 & \text{if respondent was not allocated to booklet situation} \\
1 & \text{was allocated to booklet situation}
\end{cases}
\]

\[
V6 = \begin{cases} 
0 & \text{if respondent did not give first preference to the teacher situation in question 4} \\
1 & \text{did give first preference to the teacher situation in question 4}
\end{cases}
\]

\[
V7 = \begin{cases} 
0 & \text{if respondent did not give first preference to the microfiche situation in question 4} \\
1 & \text{did give first preference to the microfiche situation in question 4}
\end{cases}
\]
A.3 Further Analysis of Questionnaire Data Contd.

V8 = 0 if respondent did not give first preference to the booklet situation in question 4
    = 1 " " did give first preference to the booklet situation in question 4

V9, V10, V11 are the corresponding variables for the respondent's least preferred situation (question 3)

V12 = 0 if respondent did not give first preference to the "teacher only" situation in question 6
    = 1 " " did give first preference to the "teacher only" situation in question 6

V13 = 0 if respondent did not give first preference to the "microfiche by itself" option in question 6
    = 1 " " did give first preference to the "microfiche by itself" option in question 6

V14 = 0 if respondent did not give first preference to the "microfiche with teacher" option in question 6
    = 1 " " did give first preference to the "microfiche with teacher" option in question 6

V15 = 0 if respondent did not give first preference to the "booklets only" option in question 6
    = 1 " " did give first preference to the "booklets only" option in question 6

V16 = 0 if respondent did not give first preference to the "booklets with teacher" option in question 6
    = 1 " " did give first preference to the "booklets with teacher" option in question 6

V17 = 0 if respondent did not want to see microfiche viewers in the school resource unit i.e. answered "No" to question 7 (a)
    = 1 " " did want to see microfiche viewers in the school resource unit i.e. answered "Yes" to question 7 (a)

V18 is the corresponding variable based on responses to part (b) of question 7. Obviously when V17 = 0, V16 = 1 and when V17 = 1, V18 = 0

V19 = 0 if respondent found his or her method difficult
    = 1 " " easy

V20 = 0 " " easy
    = 1 " " difficult
A.3 Further Analysis of Questionnaire Data Contd.

complete data on the computer cards one can later check the correlation
table (see below) to see whether the variables have been processed correctly.

\[ V21 = 0 \text{ if respondent did not give first preference to one of the two } \]
\[ \text{microfiche options in question 6} \]
\[ = 1 \quad \text{"} \text{did give first preference to one of the two} \]
\[ \text{microfiche options in question 6} \]
\[ V22 = 0 \text{ if respondent did not give first preference to one of the two } \]
\[ \text{booklet options in question 6} \]
\[ = 1 \quad \text{"} \text{did give first preference to one of the two booklet options in question 6} \]
\[ V23 = 0 \text{ if regular teacher of respondent is female} \]
\[ = 1 \quad \text{"} \text{male} \]

We can now use the SPSS sub-programme NONPAR, for example, to put out a
table of Spearman correlations for the variables V1 to V23 together with the
significances of the correlations. Here we are not controlling for one
variable or set of variables while looking at the correlation between another
two but simply looking at direct relationships.

Table A-3-1 shows the correlation matrix. "NS" indicates "not significant",
"S" significant to the 0.05 level and "SS" significant to the 0.001 level.
Values of \( r \) are not shown where the correlations are not significant.

We see that \( r_{19,20} \) and \( r_{17,18} \) are each -1 as expected.

There is no relationship between intelligence and any of the other variables
as was found in the previous analysis. However, girls have a
tendency to prefer the teacher situation in question 6 and to avoid the micro-
fiche option in question 6.

There is a significant relationship between allocated and preferred teaching
situations with \( r_{3,6} = 0.35 \) and \( r_{3,7} \) and \( r_{3,8} = -0.13 \) and -0.30 respectively.
Students allocated to the teacher situation have a strong tendency to give
the teacher situation their first preference and to avoid booklets. However
their tendency to avoid the microfiche situation is much less pronounced.
In the same way \( r_{4,6} = 0.31 \) and \( r_{4,7} \) and \( r_{4,8} \) are -0.11 and -0.27 respectively indicating that students allocated to the microfiche situation have a
A.3 Further Analysis of Questionnaire Data Contd.

strong tendency to give that situation their first preference and to avoid booklets, however their tendency to avoid the teacher situation is much less pronounced.

For the booklet group $r_{5,6} = -0.25$, $r_{5,7} = -0.17$ and $r_{5,8} = 0.58$. The latter is quite high indicating that there is a very strong tendency for students allocated to the booklet group to prefer booklets, however there is no longer a strong tendency to avoid either one of the other situations.

We would expect $r_{6,9}$, $r_{7,10}$ and $r_{8,11}$ to be very significant and negative as only three teaching situations were available in questions 4 and 5. The table shows this to be the case. In the same way we would expect $r_{6,12}$, $r_{7,13}$, $r_{7,14}$, $r_{8,15}$, $r_{8,16}$ all to be highly significant as a respondent preferring one teaching situation in question 4 would tend to choose a similar or related situation in question 5.

There is again a strong tendency for students allocated to the booklet situation to give this situation their first preference in question 5, especially the "booklets with teachers" option ($r_{5,16} = 0.35$ while $r_{5,15} = 0.17$). There is a smaller tendency for students allocated to the other situations to prefer those situations solely upon the basis of such allocation alone.

Respondents wanting to see microfiche viewers in the resource centre tended to be students preferring the microfiche option and not preferring the lecture option in questions 4 and 5 (e.g. $r_{17,6} = -0.28$ and $r_{17,7} = 0.26$).

There is no correlation between respondents finding their method easy or difficult and their allocated situation. However students who found the teacher situation difficult tended to avoid the "teacher only" option to question 6 ($r_{19,12} = -0.15$).

Sex of teacher is having no significant effect except that respondents with a male teacher have a tendency to prefer one of the booklet options in question 6. As this is only just significant at the 0.05 level it is probably a random effect in view of the large numbers of variables involved in the analysis.

The above discussion is not meant to be exhaustive and is only given to complement the discussion in the main text by showing that a number of approaches
A.3 Further Analysis of Questionnaire Data Contd.

are available in analysing survey data. The researcher should select whichever approach is most convenient for his own specific objectives.

A similar analysis was carried out with the Kilkenny College of Further Education Stage 1 subjects but for brevity is not discussed here. More sophisticated computer methods are also available although often these may sometimes lead to results which are difficult to interpret.
APPENDIX 4

Residual Analysis

This was discussed briefly in Section 5.3.3. In the discussions of empirical results, Sections 8 to 10, there was insufficient space available to discuss the analysis of residuals for the individual sets of regression data and this appendix must also, of necessity, be brief. Fuller details are given in the SPSS manual and references cited there for readers interested in pursuing the subject further (144).

Representative results only are presented here. Residuals $Y - Y^1$ obtained from the SPSS REGRESSION print-out are plotted either against the dependent variable $Y$ or the predicted value of the independent variable $Y^1$.

From Figure A-4-1 we see that, as $Y$ increases from the origin $Y - Y^1$ is negative for the first points encountered then tends to be about zero and finally becomes positive. $X$ is the independent variable in this simple 2 dimension illustration.

However as $Y^1$ increases i.e. as we move along the regression line from the extreme left hand value of $Y^1$, $Y - Y^1$ should, for a good regression fit, tend to be neither negative nor positive but to have a mean value of zero throughout the range of $X$ and $Y$ values considered.

Not only must $Y - Y^1 = 0$ throughout the range however, the variance of the $Y - Y^1$ values must be uniform so that the $Y$ values are equally distributed about the $Y^1$ value throughout the range. Also if one particular $Y - Y^1$ value is positive or negative there must be no trend for subsequent values to be of the same sign.

If $Y$ is not a linear function of $X$, then $Y^1$, which is a linear prediction from $X$, clearly will not, on the average, fall an equal distance from $Y$ throughout the range of $X$ and $Y$ considered. One must then decide whether to add multiplicative or other terms or to carry out an appropriate data transformation.

To check whether the residuals, $Y - Y^1$, are normally distributed about zero an $x^2$ test can be carried out on the residual print-out of the SPSS REGRESSION sub-programme. One can also check the print-out for "outliers" or $Y - Y^1$ values lying more than two standard deviation units from the $Y - Y^1 = 0$ axis. The original data for these cases can then be checked to see whether it is genuine or whether a mistake had been made in punching the cards or in the handling of "missing data" etc.

Figures A-4-1 to A-4-8 show the residuals plotted against $Y$ or $Y^1$ or both for some
Fig. A-4-1
Hypothetical distribution of $X, Y$
values, showing regression line
A.4 Residual Analysis Contd.

representative sets of data. In all cases apart from the "outliers" which never constituted more than a few percent of the total number of cases the statistical requirements are quite well complied with. Also $\chi^2$ tests showed that the distribution of residuals was close to normal. These results, of course, justify the use of the linear regression analysis in this application.
Fig. A-1-2
Simultaneous Equations
Self-paced students
Simultaneous Equations
Post-test One

Fig. A-4-3
Fig. A-4-4
Stage One Science
Final Mark
TO B2

1.0
1.1
1.25

2.0
2.2
2.5

18
22
28
Fig. A-4-6
Stage One Science
First Post-test Scores
Fig. A-4-7

Percentages
Post-test one
Fig. A-4-B
Simultaneous Equations Data
First Posttest Scores
APPENDIX 5

Factor Analysis for Woodville High School Data

In this short discussion it is assumed that the reader has some familiarity with factor analysis methodology and terminology. Full discussions of these are to be found in, for example, Child and Nie et al.

In Section 10.4 it was suggested that the variables Pre-test score, Post-test 1 score, Post-test 2 score, interest and concentration, mathematical ability, reading age, intelligence and final mark all reflect a basic underlying cognitive factor to varying degrees.

To investigate this further, the SPSS sub-programme FACTOR was employed upon the 195 W.H.S. subjects for whom the following data were available: Pre-test score, Post-test 1 score, Post-test 2 score, P-One personality measure, P-Two personality measure, intelligence, reading age, final mark, sex and mathematical aptitude.

Although sex is a dichotomous variable it was included as though it represented a continuous variable for the purposes of the analysis.

Two principal factors were extracted for a varimax rotation with Kaiser normalisation. Table A-5-1 shows the extracted factor loadings for the 10 variables considered while Figure A-5-1 illustrates the results on a factorial plane.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>FACTOR 1 LOADING</th>
<th>FACTOR 2 LOADING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>.76605</td>
<td>-.04189</td>
</tr>
<tr>
<td>Post-test 1</td>
<td>.84325</td>
<td>.06075</td>
</tr>
<tr>
<td>Post-test 2</td>
<td>.87013</td>
<td>.13947</td>
</tr>
<tr>
<td>P-One</td>
<td>.02799</td>
<td>.71242</td>
</tr>
<tr>
<td>PP-Two</td>
<td>.58808</td>
<td>.59441</td>
</tr>
<tr>
<td>Intelligence</td>
<td>.84750</td>
<td>.00598</td>
</tr>
<tr>
<td>RA</td>
<td>.72518</td>
<td>-.04157</td>
</tr>
<tr>
<td>FM</td>
<td>.86444</td>
<td>.17325</td>
</tr>
<tr>
<td>Sex</td>
<td>-.06169</td>
<td>.63614</td>
</tr>
<tr>
<td>MA</td>
<td>.89928</td>
<td>.04516</td>
</tr>
</tbody>
</table>

* PP-Two is equal to -(P-Two).
FIG. 4-5-1

GRAPICAL REPRESENTATION OF PCI LENGTH.

+ "PRE-TEST"
0 "POST-TEST"
1 "POST-TEST 1"
3 "POST-TEST 2"
6 "STILL"
3 "STILL"
1 "STILL"
APPENDIX 5 Contd.

The horizontal factor is clearly identified as intelligence/achievement/motivation, while the vertical factor reflects a personality/sex dimension. PP-Two on the figure is equivalent to -(P-Two) the sign change being for convenience of representation so that the second personality factor falls into the first rather than the third quadrant.

PP-Two loads about equally on both factors but P-One, the "extraversion" measure, only loads on the personality/. . . factor. All of the "cognitive factors" fall closely together close to the horizontal factor with Post-test 1 scores in the middle of the cluster. Clearly method effects must be very small in determining Post-test 1 scores (as well, of course, as Post-test 2 scores). Pre-test scores, intelligence, etc., are excellent predictors and fall, with Post-test scores, close to the horizontal axis.
PRE-TEST: Powers of Ten

1. What is the square of ten?
2. What is the value of $10^6$?
3. What is the value of $10^{-3}$?
4. Express 5250 in terms of a number multiplied by ten, when ten is raised to a power.
5. Express 0.0125 in terms of a number multiplied by ten, when ten is raised to a power.
6. Simplify and eliminate powers of ten in $\frac{10^5}{10^2}$.
7. Simplify and eliminate powers of ten in $10^5 \times 10^{-2}$.
8. Express $400 \times 0.125$ in terms of a number multiplied by ten when ten is raised to a power.
9. Express $10^4 \times 10^{-7} \times 1250$ in terms of a number multiplied by ten with ten raised to a power.
10. Express $\frac{10^3 \times 1 \times 0.001}{2000}$ in terms of a number multiplied by ten, with ten raised to a power.
11. Rewrite the following number using scientific notation 271.6.
12. Express $1000 \times 1\ 000\ 000$ in terms of powers of ten.
13. Evaluate $2 \times 10^2 \times 1.25$ and express answer in standard form.
14. Rewrite the following using powers of ten $0.0069$.
15. Express the following in standard form and evaluate giving answer in standard form.

$$\frac{1}{4000 \times 0.00025 \times 0.000125}$$

16. The age of the earth is estimated to be 694 000 000 000 days. Rewrite this number using scientific notation.

Evaluate the following and express all answers in standard form.

17. \( \frac{10^6}{10^5} \)

18. \( \frac{10^3 \times 10^b}{10^2} \)

19. \( 7 \times 10^2 \times 10^4 \times \frac{1}{100} \)

20. \( \frac{10^5}{10^{-b}} \)
Time Started: 
Time Finished: 
Name: 

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POST-TEST 1: Powers of Ten

1. What is the square of ten?
2. What is the value of $10^8$?
3. What is the value of $10^{-7}$?
4. Express 7970 in terms of a number multiplied by ten when ten is raised to a power.
5. Express 0.0272 in terms of a number multiplied by ten, when ten is raised to a power.
6. Simplify and eliminate powers of ten in $10^{12}/10^7$
7. Simplify and eliminate powers of ten in $10^6 \times 10^{-4}$
8. Express $300 \times 0.225$ in terms of a number multiplied by ten, when ten is raised to a power.
9. Express $10^6 \times 10^{-8} \times 8270$ in terms of a number multiplied by ten when ten is raised to a power.
10. Express $10^8 \times \frac{1}{1000} \times 0.002$ in terms of a number multiplied by ten when ten is raised to a power.
11. Rewrite the following number using scientific notation: 3516.71
12. Express 10 000 x 100 in terms of powers of ten.
13. Evaluate $0.0625 \times 80 \times 10^3$ and express your answer in standard form.
14. Rewrite the following using powers of ten: 0.0871.
15. Express the following in standard form and evaluate giving answer in standard form: $\frac{1}{4000 \times 0.5 \times 0.0002}$
16. The age of the moon is estimated to be 718 000 000 000 days. Rewrite this number using scientific notation.

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POST-TEST 1: Powers of Ten Contd.

Evaluate the following and express all answers in standard form.

17. \( \frac{10^8}{10^3} \)

18. \( \frac{10^6 \times 10^{-2}}{10^3} \)

19. \( 2.5 \times 10^3 \times 10^2 \times \frac{1}{1000} \)

20. \( \frac{10^7}{10^{-2}} \)
POST-TEST 2: Powers of Ten

1. What is the square of ten?
2. What is the value of $10^3$?
3. What is the value of $10^{-4}$?
4. Express 4520 in terms of a number multiplied by ten, when ten is raised to a power.
5. Express 0.0315 in terms of a number multiplied by ten, when ten is raised to a power.
6. Simplify and eliminate powers of ten in $\frac{10^7}{10^4}$.
7. Simplify and eliminate powers of ten in $10^9 \times 10^{-5}$.
8. Express $600 \times 0.250$ in terms of a number multiplied by ten, when ten is raised to a power.
9. Express $10^6 \times 10^{-3} \times 1550$ in terms of a number multiplied by ten, when ten is raised to a power.
10. Express $10^{11} \times \frac{1}{3000} \times 0.006$ in terms of a number multiplied by ten, when ten is raised to a power.
11. Rewrite the number 960.2 using scientific notation.
12. Express $10,000 \times 1,000,000$ in terms of powers of ten.
13. Evaluate $4 \times 10^4 \times 4.4$ and express in standard form.
14. Rewrite the following using powers of ten - 0.00715.
15. Express the following in standard form and evaluate, giving the answer in standard form.

$$\frac{1}{5,000 \times 0.00025 \times 0.0006}$$

16. The size of an atom is about 0.0000000005 metres. Rewrite this number using scientific notation.
Evaluate the following and express your answer in standard form.

17. \( \frac{10^6}{10^3} \)

18. \( \frac{10^9 \times 10^3}{10^7} \)

19. \( 7 \times 10^4 \times 10^5 \times \frac{1}{1000} \)

20. \( \frac{10^7}{10^{-3}} \)
PRE-TEST: Algebraic Equations

1. Given $3x = 12$.
   Find the value of $x$.

2. Given $5a - 6 = 19$.
   Find the value of $a$.

3. Given $E = R \times I$.
   Find the value of $I$ in terms of $E$ and $R$.

4. Given $x = \frac{y + 2}{3}$
   Find the value of $y$.

5. Given $\frac{a + 4}{3} = 2$
   Find the value of $a$.

6. Find $A$ if $4B = \frac{3}{A} + B$.

7. Find $E$ given
   $4 = \frac{4 - 2}{E}$

8. Find $x$ if
   $4y = \frac{3}{x} + y$

9. If $7x - 5 = 44$
   Find $x$.

10. Given $5x + 2a = 4$
    Find $a$. 
11. Given $5x = 20$, 
Find the value of $x$.

12. Given $7x - 5 = 16$, 
Find the value of $x$.

13. Given $G = B \times 2$, 
Find the value of $Z$ in terms of $G$ and $B$.

14. Given $5x + 8 = 24$, 
Find the value of $x$.

15. Given $3x - 4.7 = 2.8$, 
Find the value of $x$.

16. Given $3x - 5 = 2x + 3$, 
Find the value of $x$.

17. Find $x$, given that $2x + 6 = 14 - 3x$.

18. Given $\frac{3x}{5} - \frac{2}{5} = 0$. 
Find the value of $x$.

19. Given $3x - 2(x + 4) = 5x - 28$, 
Find the value of $x$.

20. Given $\frac{3x + 1}{4} = 1 + \frac{3}{4}$, 
Find the value of $x$. 
POST-TEST 1: Algebraic Equations

1. Given $11x = 121$,
   Find the value of $x$.

2. Given $7u - 3 = 39$,
   Find the value of $u$.

3. Given $G = R \times 2$,
   Find the value of $z$ in terms of $G$ and $R$.

4. Given $x = 2 + 3$,
   \[ \frac{4}{\frac{5}{x}} \]
   Find the value of $z$.

5. Given $b + 1 = -2$,
   \[ \frac{5}{\frac{5}{b}} \]
   Find the value of $b$.

6. Find $x$ if $10 + y = 5y$

7. Find $E$ given that $9 = 8 - 7\frac{E}{x}$

8. Find $z$ if $8y = 6 + 2y$

9. If $6g - 8 = 40$,
   Find the value of $g$.

10. Given $3b + 6a = 5$,
    Find the value of $a$.

11. Given $7x = 49$,
    Find the value of $x$.

12. Given $8y - 5 = 35$,
    Find the value of $y$.

13. Given $U = 2 \times G$,
    Find the value of $G$ in terms of $U$ and $Z$.

14. Given $4a + 9 = 32$,
    Find the value of $a$.

15. Given $5x - 5.2 = 2.3$,
    Find the value of $x$.  

ATTEMPT ALL QUESTIONS
16. Given $5x + 6 = 4x - 4$,
Find the value of $x$.

17. Given $6x + 2 = 16 - 2x$,
Find the value of $x$.

18. Given $6x - \frac{3}{4} = 0$,
Find the value of $x$.

19. Given $6a - 3(a + 2) = 2a - 15$,
Find the value of $a$.

20. Given $\frac{5a + 1}{6} = \frac{2 + 1}{3}$
Find the value of $a$. 
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POST-TEST 2: Algebraic Equations

1. Given $7x = 84$, find the value of $x$.
2. Given $6a - 5 = 25$, find the value of $a$.
3. Given $F = M \times A$, find the value of $A$ in terms of $F$ and $M$.
4. Given $x = \frac{y}{5} + 4$, find the value of $y$.
5. Given $\frac{a}{2} + 3 = 6$, find the value of $a$.
6. Find $A$ if $4B = \frac{3}{A} - B$.
7. Find $E$ given $10 = \frac{E}{2} + 4$.
8. Find $x$ if $5y = y - \frac{2}{x}$.
9. If $6g - 11 = 25$, find $g$.
10. Given $3x + 2a = 7$, find $a$.
11. Given $9x = 81$, find $x$.
13. Given $E = I \times R$, find the value of $I$ in terms of $E$ and $R$.
14. Given $9x + 7 = 18$, find the value of $x$. 

ATTEMPT ALL QUESTIONS
15. Given $4x - 3.7 = 5.3$
   Find $x$.  

16. Given $5x - 4 = 3x + 18$
   Find the value of $x$.  

17. Find $x$, given that $3x + 7 = 15 - x$.  

18. Given $\frac{x^2}{5} - \frac{3}{5} = 0$
   Find $x$.  

19. Given $6x - 5(x - 4) = 7x - 20$
   Find $x$.  

20. Given $\frac{3x}{4} + \frac{1}{8} = \frac{1}{2} + 3$
   Find $x$.
1. Given \( y = 2x \) and \( 3x + 2y = 21 \) Find the values of \( x \) and \( y \).

2. If \( x = 5y - 3 \) and \( 3x - 8y = 12 \) Determine the values of \( x \) and \( y \).

3. Find the values of \( a \) and \( b \), if 
   \[
   2a - b = 10 \\
   3a + 2b = 29
   \]

4. Given \( 3a - 2(b + 3) = 2 \) and \( 2(a - 3) + 4 = 3b - 5 \) Determine the values of \( a \) and \( b \).

5. If \( \frac{x}{2} - \frac{y}{5} = 1 \) and \( y - \frac{x}{3} = 8 \) Find the values of \( x \) and \( y \).

6. Solve for \( h \) and \( k \), 
   \[
   5h - 3k = 34 \\
   15h + 12k = 39
   \]

7. The currents in amperes in two wires are such that \( 5I_1 = 7I_2 \), and \( 8(I_1 + I_2) + 12I_2 = 156 \). Determine the values of \( I_1 \) and \( I_2 \).

8. John buys six electric bells and ten electric lamps for $6.00. If he had bought five bells and four lamps, he would have paid $3.70. What was the cost of each article purchased?

9. The total purchase price for a pair of scissors and a camping knife is $6.70. Find the cost of the scissors and the cost of the knife, if two pairs of scissors and one knife cost $7.90.

10. If 3 people went to the drive-in movies and bought 2 ice-creams and the total cost of their tickets and the ice-creams was $6.60, and if 2 people went to the same show and bought 3 ice-creams and the total cost of their tickets and ice-creams was $4.90, find the cost of a ticket and the cost of an ice-cream.
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POST-TEST 1: Simultaneous Equations.

1. Given \( a + 2b = 25 \) and \( a + b = 10 \) find the values of \( a \) and \( b \).

2. If \( 2a + 3 = 31 \) and \( a - b = 6 \) determine the values of \( a \) and \( b \).

3. Find the values of \( x \) and \( y \), if \( 4x + y = 1000 \) and \( 2x - y = 2000 \).

4. Given \( 2x + 2(y + 2) = 6 \) and \( 2(x + 2) = y + 9 \) determine the values of \( x \) and \( y \).

5. If \( \frac{c}{2} + \frac{d}{5} = 2 \) and \( c + 2d = 12 \) find the values of \( c \) and \( d \).

6. Solve for \( x \) and \( y \).
   \[
   \begin{align*}
   100x + 20y &= 1000 \\
   30x + 25y &= 870 \\
   \end{align*}
   \]

7. The force \( (E) \) applied to a machine and the resistance \( (R) \) to be overcome are connected by the law \( E = a + bR \). It is found that when \( E = 3.5 \), \( R = 5 \), and when \( E = 5.3 \), \( R = 8 \). Find \( a \) and \( b \).

8. There are two numbers, \( x \) and \( y \), such that the sum of \( 2x \) and \( y \) is 34, while the sum of \( x \) and \( 2y \) is 32. What are the numbers?

9. If 2 pies and 3 pasties cost $1.35, and if 3 pies and 1 pasty cost $1.15, work out the cost of a pie and the cost of a pasty.

10. Given that the combined cost of a motorcycle and a car is $5500. Find the cost of a motorcycle and the cost of a car if the combined cost of 3 motorcycles and 2 cars is $11,500.
POST-TEST 2: Simultaneous Equations

ATTEMPT ALL QUESTIONS

1. Given \(2a + b = 15\)
   \(a + b = 9\)
   Find \(a\) and \(b\).

2. If \(4a + 3 = 19\)
   \(a - b = 3\)
   Find \(a\) and \(b\).

3. Find \(x\) and \(y\) if
   \(3x - y = 2000\)
   \(2x + y = 500\)

4. Given \(3x + 2(y + 1) = 2\)
   \(2(x + 1) = y + 7\)
   Find \(x\) and \(y\).

5. If \(a + b = 4\)
   \(\frac{3}{5} + \frac{5}{x} = b\)
   Find \(a\) and \(b\).

6. Solve for \(x\) and \(y\),
   \(100x - 10y = 0\)
   \(3y + 5x = 175\)

7. The force \((F)\) applied to a machine and the resistance \((R)\) to be overcome are connected by the law \(E = a - \frac{1}{2} bR\) where \(a\) and \(b\) are constants. If it is found that \(E = 0.875\) when \(R = 0.5\) and \(E = 0.95\) when \(E = 0.95\), find \(a\) and \(b\).

8. If there are 2 numbers \(x\) and \(y\) such that the sum of \(x\) and \(2y\) is 31, and if the sum of \(2x\) and \(y\) is 32, find the numbers.

9. If 2 pies and 5 pasties cost 90¢, and 3 pies and 2 pasties cost 69¢, find out how much one pie costs and one pasty costs.

10. A television set and a wireless set together cost $750. Three television sets and 2 wireless sets cost $2,025. How much is one television set and one wireless set?
KILKENNY COLLEGE OF FURTHER EDUCATION
STAGE 1 TECHNICIANS MATHS. GROUP

PRE-TEST: Introducing Complex Numbers

ATTEMPT ALL QUESTIONS

Maximum Time: 30 minutes.

1. What is $j^2$, $j^6$, $j^{100}$.

2. Simplify $\sqrt{-16}$ and $\sqrt{-49}$

3. Add the following numbers:
   
   \[
   6 + j3 \quad -12 - jk \quad j \quad 12
   \]

4. Draw on an Argand diagram the vector $A = r\theta$ for $r = 3$, $\theta = 250^\circ$.

5. Represent the vector $A = 10$, $45^\circ$ in complex form.

6. Add the vectors
   
   \[
   A = 10, 20^\circ \\
   B = 40, 90^\circ
   \]

   by writing them in complex number form. Illustrate your result graphically.

7. Convert the complex number $B = 8 + j5$ to polar form.

   Illustrate your results graphically.

8. Add the complex numbers:
   
   \[
   A = 2 + j6 \\
   B = 7 + j3
   \]

   and express your answer in polar form.

9. If 2 vectors are
   
   \[
   A = 30, 40^\circ \\
   B = 70, 120^\circ
   \]

   find, in complex form, the vectors $A + B$

   $A - B$

   $B - A$

   and draw these on an Argand diagram.

10. If $A = 6 + 5j$, then represent on an Argand diagram the numbers $C$, $D$

    and $E$ if $A + C = 6$, $A + D = 5j$ and $E = A + C + D$. 

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POST-TEST 1: Introducing Complex Numbers

1. What is \( j^2, \ j^3, \ j^{80}, \ j \).

2. Simplify \( \sqrt{-81} \) and \( \sqrt{-144} \).

3. Add the following numbers: 
   \[-3 - j7, -5, j4, 8 + j3\]

4. Draw on an Argand diagram the vector \( \mathbf{A} = r\theta \) for \( r = 5, \ \theta = 320^\circ \). Write down the real and imaginary parts of \( \mathbf{A} \).

5. Represent the vector \( \mathbf{B} = 50, 135^\circ \) in complex form.

6. Add the vectors \( \mathbf{A} = 5, 80^\circ \) and \( \mathbf{B} = 12, 120^\circ \) by writing them in complex number form. Illustrate your result graphically.

7. Convert the complex number \( \mathbf{B} = -12 + j3 \) to polar form. Illustrate your result graphically.

8. Add the complex numbers: 
   \( \mathbf{A} = 5 + j7 \)
   \( \mathbf{B} = -6 - j10 \)
   and express your answer in polar form.

9. If 2 vectors are 
   \( \mathbf{A} = 50, 60^\circ \) and \( \mathbf{B} = 70, 110^\circ \)
   find, in complex form, the vectors \( \mathbf{A} + \mathbf{B} \), \( \mathbf{A} - \mathbf{B} \), \( \mathbf{B} - \mathbf{A} \)
   and draw these on an Argand diagram.

10. If \( \mathbf{A} = 12 - 11j \) then represent on an Argand diagram the numbers \( \mathbf{C}, \ \mathbf{D} \) and \( \mathbf{E} \) if 
    \( \mathbf{A} + \mathbf{C} = 12 \)
    \( \mathbf{A} + \mathbf{D} = -11j \)
    \( \mathbf{E} = \mathbf{A} + \mathbf{C} + \mathbf{D} \).
POST-TEST 2: Introducing Complex Numbers

1. What is \( j^3 \), \( j^9 \), \( j^{50} \).

2. Simplify \( \sqrt{-625} \) and \( \sqrt{-100} \).

3. Add the following numbers:
   - \( 7 + j9 \)
   - \( -16 - j21 \)
   - \( 11 + j12 \)

4. Draw on an Argand diagram the vector \( \mathbf{A} = r \mathbf{e}^{ \theta} \) for \( r = 5 \), \( \theta = 320^\circ \). Write down the real and imaginary parts of \( \mathbf{A} \).

5. Represent the vector \( \mathbf{A} = 5, 210^\circ \) in complex form.

6. Add the vectors \( \mathbf{A} = 20, 30^\circ \)
   \( \mathbf{B} = 45, 140^\circ \)
   by writing them in complex number form. Illustrate your result graphically.

7. Convert the complex number \( \mathbf{B} = -7 - j13 \) to polar form. Illustrate your result graphically.

8. Add the complex numbers
   - \( \mathbf{A} = 12 + j8 \)
   - \( \mathbf{B} = -6 - j17 \)
   and express your answer in polar form.

9. If 2 vectors are \( \mathbf{A} = 40, 40^\circ \)
   \( \mathbf{B} = 60, 350^\circ \)
   find, in complex form, the vectors \( \mathbf{A} + \mathbf{B} \), \( \mathbf{A} - \mathbf{B} \), \( \mathbf{B} - \mathbf{A} \)
   and draw these on an Argand diagram.

10. If \( \mathbf{B} = 15 - j7 \) then represent on an Argand diagram the numbers \( \mathbf{C}, \mathbf{D}, \mathbf{E} \) if
    
    - \( \mathbf{B} + \mathbf{C} = 15 \)
    - \( \mathbf{C} + \mathbf{D} = 7j \)
    - \( \mathbf{E} = \mathbf{B} + \mathbf{C} + \mathbf{D} \).
PRE-TEST: Introducing Vectors

1. What is the difference between a scalar and a vector quantity?
2. Is mass a vector quantity?
3. What is the modulus of a quantity?
4. What is the argument of a vector quantity?
5. Represent a force acting at an angle of $\theta$ with respect to a reference direction by drawing a vector diagram.
6. Draw to scale a force of 3 newtons acting at an angle of $30^\circ$ with respect to a reference direction. State the scale.
7. By means of a vector diagram drawn to scale, graphically find the resultant of two forces, when the first force is $200 \angle 80^\circ$ newton and the second force is $200 \angle 0^\circ$ newton. Express your answer in polar form.
8. Find graphically the vector sum of $100 \angle 30^\circ$ newton and $200 \angle 60^\circ$ newton. Express your answer in polar form.
9. By means of trigonometry, find the resultant of two forces, when the first force is $1000 \angle 30^\circ$ newton and the second force is $1000 \angle 60^\circ$. Express your answer in polar form.
10. By means of trigonometry, find the vector sum of $1000 \angle 20^\circ$ and $2000 \angle 45^\circ$. 

KILKENNY COLLEGE OF FURTHER EDUCATION
SCHOOL OF ELECTRONIC ENGINEERING
STAGE 1 TECHNICIANS MATHS. GROUP
POST-TEST 1: Introducing Vectors

ATTEMPT ALL QUESTIONS

1. Is Weight (or gravitational pull) a scalar or vector quantity?

2. Is Density a scalar or vector quantity?

3. What is the argument of a vector quantity?

4. If a car is travelling at 60 km/h, what additional information do we need to determine its velocity at any instant?

5. Represent a force acting at an angle of $-0^\circ$ with respect to a reference direction by drawing a vector diagram.

6. Draw to scale a force of 5 newtons acting at an angle of $20^\circ$ with respect to a reference direction. State the scale.

7. Find graphically the resultant of the following two forces: $100 \angle 30^\circ$ and $100 \angle 20^\circ$. Express your answer in polar form.

8. Find graphically the vector sum of $100 \angle 60^\circ$ newton and $200 \angle 30^\circ$ newton. Express the answer in polar form.

9. By means of trigonometry find the resultant of 2 forces, when the first force is $300 \angle 45^\circ$ newton and the second force is $300 \angle 60^\circ$. Express your answer in polar form.

10. By means of trigonometry find the vector sum of $1000 \angle 30^\circ$ and $3000 \angle 45^\circ$. 
KILKENNY COLLEGE OF FURTHER EDUCATION
SCHOOL OF ELECTRONIC ENGINEERING
STAGE 1 TECHNICIANS MATHS. GROUP

POST-TEST 2: Introducing Vectors

1. How does a scalar quantity differ from a vector quantity?
2. Is volume a scalar or vector quantity?
3. What is the argument of a vector quantity?
4. What is the modulus of a quantity?
5. Represent a force acting at $120^\circ$ with respect to a reference direction by drawing a vector diagram.
6. Draw to scale a force of 3 newtons acting at an angle of $-30^\circ$ with respect to a reference direction. State the scale.
7. Find graphically the resultant of the following two forces: $300 \angle 60^\circ$ newton and $300 \angle 0^\circ$ newton. Express your answer in polar form.
8. Find graphically the vector sum of $100 \angle 80^\circ$ newton and $200 \angle 10^\circ$ newton. Express your answer in polar form.
9. By means of trigonometry find the resultant of 2 forces, when the first force is $200 \angle 60^\circ$ and the second is $200 \angle 20^\circ$ newton. Express your answer in polar form.
10. By means of trigonometry find the vector sum of $2000 \angle 40^\circ$ newton and $3000 \angle 40^\circ$ newton.
KILKENNY COLLEGE OF FURTHER EDUCATION

PERCENTAGES

PRE-TEST

Secondary Students

1. If 60% of the people in South Australia live in Adelaide, what is the base of the percentage?
2. Express 75% as a fraction.
3. Express 28% as a fraction.
4. What % is 7 of 28?
5. What % is 42 of 72?
6. What % of 8 is 1.5?
7. What % of 22 is 6?
8. What % is 30 minutes of 3 hours?
9. What % of 5 kilometres is 400 metres?
10. What % of 15 sheep is 4 sheep?
11. If I am allowed 10% discount on an article which is marked $15, how much do I save?
12. In the last problem, how much must I pay?
13. If I am allowed 7½% discount on an article which is marked $12, how much do I pay?
14. If Tom ate 20% of a cake and Judy ate 25%, what % was left?
15. If Tom ate 20% of a cake and the rest was divided up equally between four other persons, what % did each person receive?
16. All of the children in a school walk to school, ride to school on bikes or come to school by bus. If 35% come by bus and 22% ride to school, what % come to school on foot?
17. What is 5% of 200 plus 15% of 150?
18. What is 20% of 80 minus 70% of 490?
19. What is 14% of 294 divided by 7% of 294?
20. What is \( \frac{7.5}{15.5} \) expressed as a percentage?

When you finish, mark the time in the "time finished" spot on the top of the page. You must not go over the 30 minutes limit.
POST-TEST 1

KILKENNY COLLEGE OF FURTHER EDUCATION
PERCENTAGES

Secondary Students

1. If 40% of the people in Australia live in New South Wales, what is the base of the percentage?
2. Express 60% as a fraction.
3. Express 78% as a fraction.
4. What % is 8 of 32?
5. What % is 64 of 88?
6. What % of 7 is 2.5?
7. What % of 24 is 4?
8. What % is 30 minutes of 5 hours?
9. What % of 4 kilometres is 600 metres?
10. What % of 20 sheep is 6 sheep?
11. If I am allowed 10% discount on an article which is marked $9, how much do I save?
12. In the last problem, how much must I pay in dollars and cents?
13. If I am allowed 7½% discount on an article which is marked $15, how much do I pay?
14. If Tom ate 25% of a cake and Judy ate 15%, what % was left?
15. If Tom ate 25% of a cake and the rest was divided up equally between three other persons, what % did each person receive?
16. All of the children in a school walk to school, ride to school on bikes or come to school by bus. If 30% walk to school and 28% come by bus, what % ride to school on bikes?
17. What is 5% of 300 plus 15% of 120?
18. What is 30% of 120 minus 80% of 640?
19. What is 22% of 305 divided by 11% of 305?
20. What is 8.5 expressed as a percentage?

When you finish, mark the time in the "time finished" spot on the top of the page. You must not go over the 30 minutes limit.
POST-TEST 2

Secondary Students

1. If 30% of the children in Woodville attend Woodville High School, what is the base of the percentage?

2. Express 35% as a fraction.

3. Express 58% as a fraction.

4. What % is 4 of 24?

5. What % is 32 of 76?

6. What % of 8 is 2.5?

7. What % of 32 is 6?

8. What % is 30 minutes of 4 hours?

9. What % of 3 kilometres is 600 metres?

10. What % of 18 sheep is 5 sheep?

11. If I am allowed 10% on an article which is marked $18, how much do I save?

12. In the last problem, how much must I pay?

13. If I am allowed 7½% discount on an article, which is marked $9, how much do I pay?

14. If Tom ate 30% of a cake and Judy ate 15%, what % was left?

15. If Tom ate 30% of a cake and the rest was divided up equally between 5 other persons, what % did each person receive?

16. All of the children in a school do mathematics, geography or history. If 30% do mathematics and 23% do history, what % are doing geography?

17. What is 5% of 400 plus 15% of 160?

18. What is 20% of 90 minus 60% of 360?

19. What is 4½% of 117 divided by 22% of 117?

20. What is 6.5 expressed as a percentage?

When you finish, mark the time in the "time finished" spot at the top of the page. You must not go over the 30 minutes limit.
KILKENNY COLLEGE OF FURTHER EDUCATION

INDUCTIVE REACTANCE

OBJECTIVES

At the end of this programme you should be able to do the following:-

1. Write a definition of inductive reactance.
2. Describe the effect on inductive reactance when the frequency of the
   applied voltage is varied and when the value of inductance is varied.
3. Write down the relationship between the alternating voltage across an
   inductor, the current through it and its inductive reactance.
4. Describe the phase angle between voltage and current in an inductor.
5. Define what is meant by a phasor.
6. Describe and draw phasor diagrams for inductors and resistors.
7. Identify and draw simple inductor and resistor circuits.
8. Draw a phasor diagram for a simple inductor and resistor series circuit
   and to solve the diagram by graphical and algebraic methods, given a
   sufficient combination of quantities for the circuit and to give the
   answers with the correct S.I. units to 2 decimal places.
9. Define impedance in terms of inductive reactance and resistance.
10. Draw the impedance triangle for a series inductor and resistor and to
    solve the triangle given suitable values.
11. Draw a phasor diagram for a simple inductor and resistor parallel circuit
    and to solve the diagram by graphical or algebraic methods, given a
    sufficient combination of quantities for the circuit and to give the
    answers with the correct S.I. units to 2 decimal places.
12. Define admittance and susceptance.
13. Draw the admittance triangle for a parallel inductor and resistor circuit
    and calculate impedance from the admittance triangle either graphically
    or algebraically given sufficient information and give the answers in
    the correct S.I. units to 2 decimal places.
KILKENNY COLLEGE OF FURTHER EDUCATION

Time Started: __________
Time Finished: __________
Name: ________________

30 minutes maximum.

INDUCTIVE REACTANCE

PRE-TEST

Stage 1 Science Students

Show all calculations and give answers correct to 2 decimal places.
Use \( 2\pi = 6.28 \), \( \frac{1}{2\pi} = 0.159 \).

1. What happens to inductive reactance when:-
   (a) frequency decreases?
   (b) inductance increases?

2. What is the inductive reactance of a 2H inductor at 100 Hz?

3. (a) What is the equation linking the sinusoidal voltage across an inductor, the current through it, and the inductive reactance?
   (b) Explain each of the terms "Inductor" and "Inductive reactance".

4. (a) Draw the voltage phasor diagram for an inductor and a resistor in series. Show the resultant voltage phasor.
   (b) What are the equations for calculating the resultant voltage and phase angle from the above phasor diagram?

5. Diagram 1.

\[ X_L = 3\Omega \quad R = 4\Omega \]

From Diagram 1, calculate:-
(a) Impedance
(b) Circuit current
(c) Voltage across \( R \)
(d) Voltage across \( X_L \)
(e) Phase angle between \( V_a \) and circuit current.

6. (a) Draw the current phasor diagram for an inductor and a resistor in parallel. Show the resultant circuit current phasor.
   (b) What are the equations for calculating the resultant circuit current and the phase angle from the above phasor diagram?

7. Diagram 2.

\[ X_L = \frac{1}{4} \Omega \]

\[ R = \frac{1}{3} \Omega \]

\[ V_a = 1 \, \text{V} \]
7. Contd.

From Diagram 2, calculate:-

(a) Current through the resistor.
(b) Current through the inductor.
(c) Resultant circuit current from supply.
(d) Impedance.
(e) Phase angle between the circuit current and the applied voltage Va.

8. What value of inductance is required to give an inductive reactance of 1 kΩ at 10 kHz?

9. (a) What is impedance?
(b) Draw the impedance triangle for an inductor and a resistor in series.

10. (a) Sketch the sinewaves for current and voltage as applied to a 'pure' inductor.

(b) Briefly explain why there is a phase difference between the two sinewaves. To aid your explanation, refer to your sketch.

When finished, clip these question sheets to your answer sheets and pass both back to your instructor or supervisor.
KILKENNY COLLEGE OF FURTHER EDUCATION

Time Started:_________   Name:_____________________
Time Finished:_______   30 minutes maximum.

INDUCTIVE REACTANCE

POST-TEST 1
Stage 1 Science Students

Show all calculations and give answers correct to 2 decimal places.
Use \( 2\pi = 6.28, \frac{1}{2\pi} = 0.159 \).

1. What happens to inductive reactance when:
   (a) frequency increases?
   (b) inductance decreases?

2. What is the inductive reactance of a 4\(H\) inductor at 150 Hz?

3. (a) What is the equation linking the sinewave voltage across an inductor, the current through it, and the inductive reactance?
   (b) Explain each of the terms "inductor" and "inductive reactance".

4. (a) Draw the voltage phasor diagram for an inductor and a resistor in series. Show the resultant voltage phasor.
   (b) What are the equations for calculating the resultant voltage and phase angle from the above phasor diagram?

5. Diagram 1.

   \[ X_L = 4\Omega \quad R = 3\Omega \]

   From Diagram 1, calculate:
   (a) Impedance
   (b) Circuit current
   (c) Voltage across R
   (d) Voltage across \(X_L\)
   (e) Phase angle between \(V_a\) and circuit current.

6. (a) Draw the current phasor diagram for an inductor and a resistor in parallel. Show the resultant circuit current phasor.
   (b) What are the equations for calculating the resultant circuit current and the phase angle from the above phasor diagram?

7. Diagram 2.

   \[ X_L = \frac{1}{3}\Omega \]
   \[ R = \frac{1}{4}\Omega \]

   \[ V_a = 2\ V \]
7. Contd.

From Diagram 2, calculate:-

(a) Current through the resistor.
(b) Current through the inductor.
(c) Resultant circuit current from supply.
(d) Impedance.
(e) Phase angle between the circuit current and the applied voltage Va.

8. What value of inductance is required to give an inductive reactance of 2 kΩ at 20 kHz?

9. (a) What is impedance?
   (b) Draw the impedance triangle for an inductor and a resistor in series.

10. (a) Sketch the sinewaves for current and voltage as applied to a 'pure' inductor.
      (b) Briefly explain why there is a phase difference between the two sinewaves. To aid your explanation, refer to your sketch.

When finished, clip these question sheets to your answer sheets and pass both back to your instructor or supervisor.
INDUCTIVE REACTANCE

POST-TEST 2

Stage 1 Science Students

Show all calculations and give answers correct to 2 decimal places.
Use \(2\pi \approx 6.28, \frac{1}{2\pi} \approx 0.159\).

1. What happens to inductive reactance when:
   (a) frequency increases?
   (b) inductance increases?

2. What is the inductive reactance of a 6\( \text{H} \) inductor at 50 Hz?

3. (a) What is the equation linking the sinewave voltage across an inductor, the current through it, and the inductive reactance?
   (b) Explain each of the terms "inductor" and "inductive reactance".

4. (a) Draw the voltage phasor diagram for an inductor and a resistor in series. Show the resultant voltage phasor.
   (b) What are the equations for calculating the resultant voltage and phase angle from the above phasor diagram?

5. Diagram 1.

   \[ X_L = 5\Omega \quad R = 2\Omega \]

   \( V_a = 12 \text{ V} \)

   From Diagram 1, calculate:
   (a) Impedance
   (b) Circuit current
   (c) Voltage across \( R \)
   (d) Voltage across \( X_L \)
   (e) Phase angle between \( V_a \) and circuit current.

6. (a) Draw the current phasor diagram for an inductor and a resistor in parallel. Show the resultant circuit current phasor.
   (b) What are the equations for calculating the resultant circuit current and the phase angle from the above phasor diagram?

7. Diagram 2.

   \[ X_L = \frac{1}{5} \Omega \]

   \[ R = \frac{1}{2} \Omega \]

   \( V_a = 1 \text{ V} \)
7. Contd.

From Diagram 2, calculate:

(a) Current through the resistor.
(b) Current through the inductor.
(c) Resultant circuit current from supply.
(d) Impedance.
(e) Phase angle between the circuit current and the applied voltage Va.

8. What value of inductance is required to give an inductive reactance of 2 k\(\Omega\) at 30 kHz?

9. (a) What is impedance?
   (b) Draw the impedance triangle for an inductor and a resistor in series.

10. (a) Sketch the sinewaves for current and voltage as applied to a 'pure' inductor.
    (b) Briefly explain why there is a phase difference between the two sinewaves. To aid your explanation, refer to your sketch.

When finished, clip these question sheets to your answer sheets and pass both back to your instructor or supervisor.
KILKENNY COLLEGE OF FURTHER EDUCATION
CAPACITANCE REACTANCE

OBJECTIVES

At the end of this programme you should be able to do the following:-

1. Write a definition of capacitive reactance.
2. Describe the effect on capacitive reactance when the frequency of the applied voltage is varied and when the value of capacitance is varied.
3. Write down the relationship between the alternating voltage across a capacitor, the current through it and its capacitive reactance.
4. Describe the phase angle between voltage and current in a capacitor.
5. Define what is meant by a phasor.
6. Describe and draw phasor diagrams for capacitors and resistors.
7. Identify and draw simple capacitor and resistor circuits.
8. Draw a phasor diagram for a simple capacitor and resistor series circuit and to solve the diagram by graphical and algebraic methods, given a sufficient combination of quantities for the circuit and to give the answers with the correct S.I. units to 2 decimal places.
9. Define impedance in terms of capacitive reactance and resistance.
10. Draw the impedance triangle for a series capacitor and resistor and to solve the triangle given suitable values.
11. Draw a phasor diagram for a simple capacitor and resistor parallel circuit and to solve the diagram by graphical or algebraic methods, given a sufficient combination of quantities for the circuit and to give the answers with the correct S.I. units to 2 decimal places.
12. Define admittance and susceptance.
13. Draw the admittance triangle for a parallel capacitor and resistor circuit and calculate impedance from the admittance triangle either graphically or algebraically given sufficient information and give the answers in the correct S.I. units to 2 decimal places.
KILKENNY COLLEGE OF FURTHER EDUCATION

Time Started: ___________________________ Name: ___________________________

Time Finished: ________________ 30 minutes maximum.

CAPACITIVE REACTANCE

PRE-TEST Stage 1 Science Students

Show all calculations and give answers correct to 2 decimal places. Use $2\pi = 6.28, \frac{1}{2\pi} = 0.159$.

1. What happens to capacitive reactance when:
   (a) frequency decreases?
   (b) capacitance increases?

2. What is the capacitive reactance of a 8μF capacitor at 100 Hz?

3. (a) What is the equation linking the sinewave voltage across a capacitor, the current through it, and the capacitive reactance?
   (b) Explain the term "capacitive reactance".

4. (a) Draw the voltage phasor diagram for a capacitor and a resistor in series. Show the resultant voltage phasor.
   (b) What are the equations for calculating the resultant voltage and phase angle from the above phasor diagram?

5. Diagram 1. $X_C = 3\Omega \quad R = 4\Omega$

   ![Diagram 1](image)

   From Diagram 1, calculate:
   (a) Impedance
   (b) Circuit current
   (c) Voltage across $R$
   (d) Voltage across $X_C$
   (e) Phase angle between $V_a$ and circuit current

6. (a) Draw the current phasor diagram for a capacitor and a resistor in parallel. Show the resultant circuit current phasor.
   (b) What are the equations for calculating the resultant circuit current and the phase angle from the above phasor diagram?
7. Diagram 2.

\[ X_C = \frac{1}{4} \Omega \]

\[ R = \frac{1}{3} \Omega \]

\[ V_a = 1 \text{ V} \]

From Diagram 2, calculate:-

(a) Current through the resistor.
(b) Current through the capacitor.
(c) Resultant circuit current from supply.
(d) Impedance.
(e) Phase angle between the circuit current and the applied voltage \( V_a \).

8. What value of capacitance is required to give a capacitive reactance of 1 \( \text{k}\Omega \) at 10 kHz?

9. (a) What is admittance?
(b) Draw the admittance triangle for a capacitor and a resistor in parallel.

10. (a) Sketch the sinewaves for current and voltage as applied to a 'pure' inductor.
(b) Briefly explain why there is a phase difference between the two sinewaves. To aid your explanation, refer to your sketch.

When finished, clip these question sheets to your answer sheets and pass both back to your instructor or supervisor.
CAPACITIVE REACTANCE
Stage 1 Science Students

Show all calculations and give answers correct to 2 decimal places.
Use $2\pi = 6.28$, $\frac{1}{2\pi} = 0.159$.

1. What happens to capacitive reactance when:
   (a) frequency increases?
   (b) capacitance decreases?

2. What is the capacitive reactance of a 5μF capacitor at 150 Hz?

3. (a) What is the equation linking the sinewave voltage across a capacitor, the current through it, and the capacitive reactance?
   (b) Explain the term "capacitive reactance".

4. (a) Draw the voltage phasor diagram for a capacitor and a resistor in series. Show the resultant voltage phasor.
   (b) What are the equations for calculating the resultant voltage and phase angle from the above phasor diagram?

5. Diagram 1.

From Diagram 1, calculate:
(a) Impedance
(b) Circuit current
(c) Voltage across R
(d) Voltage across $X_C$
(e) Phase angle between $V_a$ and circuit current.

6. (a) Draw the current phasor diagram for a capacitor and a resistor in parallel. Show the resultant circuit current phasor.
   (b) What are the equations for calculating the resultant circuit current and the phase angle from the above phasor diagram?
7. Diagram 2.

From Diagram 2, calculate:

(a) Current through the resistor
(b) Current through the capacitor
(c) Resultant circuit current from supply
(d) Impedance
(e) Phase angle between the circuit current and the applied voltage $V_a$.

8. What value of capacitance is required to give a capacitive reactance of 2 kΩ at 20 kHz?

9. (a) What is impedance?
   (b) Draw the impedance triangle for a capacitor and a resistor in series.

10. (a) Sketch the sinewaves for current and voltage as applied to a 'pure' capacitor.
    (b) Briefly explain why there is a phase difference between the two sinewaves. To aid your explanation, refer to your sketch.

When finished, clip these question sheets to your answer sheets and pass both back to your instructor or supervisor.
KILKENNY COLLEGE OF FURTHER EDUCATION

Time Started: ___________  Name: ________________________
Time Finished: _________  30 minutes maximum.

CAPACITIVE REACTANCE

POST-TEST 2

Stage 1 Science Students

Show all calculations and give answers correct to 2 decimal places. Use $2\pi = 6.28$, $\pi = 0.159$.

1. What happens to capacitive reactance when:
   (a) frequency decreases?
   (b) capacitance decreases?

2. What is the capacitive reactance of $4\mu F$ capacitor at $300$ Hz?

3. (a) What is the equation linking the sinewave voltage across a capacitor, the current through it, and the capacitive reactance?
    (b) Explain the term "capacitive reactance".

4. (a) Draw the voltage phasor diagram for a capacitor and a resistor in series. Show the resultant voltage phasor.
    (b) What are the equations for calculating the resultant voltage and phase angle from the above phasor diagram?

5. Diagram 1.

   From Diagram 1, calculate:
   (a) Impedance
   (b) Circuit current
   (c) Voltage across $R$
   (d) Voltage across $X_C$
   (e) Phase angle between $V_a$ and circuit current.

6. (a) Draw the current phasor diagram for a capacitor and a resistor in parallel. Show the resultant circuit current phasor.
    (b) What are the equations for calculating the resultant circuit current and the phase angle from the above phasor diagram?
7. Diagram 2.

From Diagram 2, calculate:-
(a) Current through the resistor
(b) Current through the capacitor
(c) Resultant circuit current from supply
(d) Impedance
(e) Phase angle between the circuit current and the applied voltage $V_a$.

8. What value of capacitance is required to give a capacitive reactance of 5 kΩ at 150 kHz?

9. (a) What is susceptance?

(b) Draw the admittance triangle for a capacitor and a resistor in parallel.

10. (a) Sketch the sinewaves for current and voltage as applied to a 'pure' capacitor.

(b) Briefly explain why there is a phase difference between the two sinewaves. To aid your explanation, refer to your sketch.

When finished, clip these question sheets to your answer sheets and pass both back to your instructor or supervisor.
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QUESTIONNAIRE - KILKENNY COLLEGE OF FURTHER EDUCATION STUDENTS -
COMPARISON OF TEACHING METHODS

Tick appropriate answers. Name:______________________________

1. What is your academic background?
   (a) Leaving with a pass in Mathematics I & II of Grade 4 or higher; or better
   (b) Leaving, with a pass in Mathematics III of Grade 4 or better, or Mathematics I & II at Grades 5 or 6
   (c) Leaving, but less than in (b) above
   (d) Intermediate Mathematics
   (e) Less than Intermediate Mathematics
   (f) Completed other trade (an apprentice course) or higher studies
   (g) Completed schooling in another State or country
   (h) None of these.

2. Did you receive more than 5 years of your education in another language (other than English)?
   (a) Yes
   (b) No

3. (a) Is this your first year at work or out of school?
      (i) Yes
      (ii) No
   (b) What is your age?
      (i) 15 - 17
      (ii) 18 - 20
      (iii) 21 - 25
      (iv) 26 - 30
      (v) 31 - 40
      (vi) 41 - 50
      (vii) over 50

4. What is your marital status?
   (a) Single
   (b) Married
   (c) Married with children.
5. What is your reason for doing the course?
   (a) To gain skilled occupational training for the first time.
   (b) To gain skilled occupational training for the first time in this country.
   (c) To enlarge upon currently held occupational training.
   (d) Interest only.

6. Which group were you in for the tests?
   (a) Group 1
   (b) Group 2
   (c) Group 3
   (d) Group 4
   (e) Group 5.

7. By which method would you prefer to study?
   Give your preferences by marking 1 - 8 next to the options below.
   (a) Lectures and tutorials as they are at present.
   (b) Lectures and tutorials in smaller classes of about 10-12 students.
   (c) Microfiche viewers available 2 nights a week for 3 hours at a fixed time, for individual use.
   (d) Microfiche viewers available 2 nights a week for 3 hours at a fixed time, for use in small groups of 3-4 students.
   (e) Microfiche viewers available every night for individual use.
   (f) Microfiche viewers available every night for use in small groups of about 3-4 students.
   (g) Individually with booklets that can be taken home.
   (h) Small groups of 3-4 students with booklets that can be taken home.
8. By which method would you prefer to study, if an academic tutor is also available.

Give your preference by marking 1-8 next to the options below.

(a) Microfiche viewers with an academic tutor available 2 nights a week for 3 hours at fixed times, for individual use.
(b) Microfiche viewers with an academic tutor available 2 nights a week for 3 hours at fixed times, for use in small groups of 3-4 students.
(c) Microfiche viewers with an academic tutor available every night, for individual use.
(d) Microfiche viewers with an academic tutor available every night for use in small groups of 3-4 students.
(e) Individually with booklets that can be taken home and an academic tutor available.
(f) Small groups of 3-4 students with booklets that can be taken home, and an academic tutor available.
(g) Lectures and tutorials in smaller classes of 10-12 students.
(h) Lectures and tutorials as they are at present.

9 Answer only if you are under 25 years of age.

The qualifications gained from this course, will give you an occupation

(a) Better than your father
(b) Like your father
(c) Lesser than your father.

10. (a) When using the microfiche viewer did you find it

(i) Easy to use
(ii) Difficult to use
(iii) State why.

(b) When using the booklets, did you find it

(i) Easy to use
(ii) Difficult to use
(iii) State why.

(c) When attending lectures, did you find them

(i) Easy to follow
(ii) Difficult to follow
(iii) State why.
**KILKENNY COLLEGE OF FURTHER EDUCATION**

**QUESTIONNAIRE - WOODVILLE HIGH SCHOOL STUDENTS - COMPARISON OF TEACHING METHODS**

1. **Name:**

2. **Class:**

3. **What teaching method did you have?**
   - (a) Teacher only
   - (b) Microfiche
   - (c) Booklet

4. **Which method do you feel you like best?**
   - (a) Teacher only
   - (b) Microfiche
   - (c) Booklet

5. **Which method do you feel you like least?**
   - (a) Teacher only
   - (b) Microfiche
   - (c) Booklet

6. **Which method would you like to see used in your school?**
   - (a) Teacher only
   - (b) Microfiche by itself
   - (c) Microfiche with teacher to answer questions
   - (d) Booklets alone
   - (e) Booklets with teacher to answer questions
   
   If possible, indicate your order of preference.

7. **Would you like to see microfiche readers available in the resource centre or open space unit for you to work on when you feel like it?**
   - (a) Yes
   - (b) No

8. **If you used the microfiche viewer, did you find it easy to use?**
   - (a) Yes
   - (b) No

   If you did not find it easy to use, why not? ________________

   **----------**

   **----------**

   **----------**

8. **If you used the booklet, did you find it easy to use?**
   - (a) Yes
   - (b) No

   If you did not find it easy to use, why not? ________________

   **----------**

   **----------**

   **----------**

8. **If you attended the lesson with the teacher, did you find it easy to follow?**
   - (a) Yes
   - (b) No

   If you did not find it easy to follow, why not? ________________

   **----------**

   **----------**

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KILKENNY COLLEGE OF FURTHER EDUCATION

QUESTIONNAIRE FOR TEACHERS/LECTURERS

CLASS ___________________________ SCHOOL OR COLLEGE ___________________________

1. Do you think that microfiche is a valuable and viable instructional medium?
   Yes □ No □ Don't know □

2. If your answer is "yes", do you think that microfiche is particularly valuable in your School or College, for
   (a) independent self-paced learning
   or (b) self-paced learning with a tutor or teacher present to answer questions
   or (c) as a "back-up" resource with the teacher setting the pace through the programme
   or (d) other (please elaborate)

3. Do you feel microfiche viewers should be made available in the resource centre or open space unit of your School or College for students and teachers to use at their convenience
   (a) for self-paced courses? Yes □ No □
   (b) or other purposes?

4. As a teacher, do you see any serious problems arising from the use of microfiche as an instructional medium? If so what do you feel these problems to be.

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
5. What, if any, do you consider to be the advantages of microfiche over other instructional media.

6. Other comments