THE IMPACT OF THE INCLUSION OF ASEP MATERIALS ON SOME COGNITIVE OUTCOMES IN TASMANIAN SCHOOLS

by

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This thesis contains no material which has been accepted for the award of any other degree or diploma in any university, and to the best of the candidate's knowledge and belief, the thesis contains no paraphrase of material previously published or written by another person, except when due reference is made in the text of the thesis.

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ABSTRACT

The Australian Science Education Project (ASEP) was the first national curriculum project to exist in Australia, and was sponsored jointly by the Commonwealth government and the six State governments. The initial funding was $1.2 million for a period of 4½ years, and the charter of the project was to develop instructional materials in science for grades 7 to 10 in secondary schools throughout Australia.

At the beginning of 1974 the materials developed by the project were available for inclusion in the science curriculum of Tasmanian schools. This study examines the influence of the inclusion of ASEP materials on some cognitive outcomes,for the science curriculum of grade 7 classes in Tasmanian schools.

The cognitive outcomes chosen are considered to be important by experts in science education. Three outcomes selected were contained in the Test of Understanding Science (TOUS) and are named 'philosophical', 'historic-social', and 'normality of scientists'. In addition four outcomes were selected from the Test of Enquiry Skills (TOES) and are named 'library usage', 'scales', 'charts and tables' and 'comprehension of science reading'.

Other student variables chosen for investigation were the students' sex, their socio-economic status and the type of school they attended.

All secondary schools in Tasmania were invited to participate and the response rate was 57%. The final sample contained 2373 students.

Following a pre and post-test of both TOUS and TOES, the data was interpreted by means of a multiple regression model which used a full regression analysis for each of the seven scales. By this method, the amount of variance in each of the seven post-tests, due to each of the main effect variables (curriculum, sex, socio-economic status and school type) was estimated over and above that due to the pretest and the other main effect variables. In addition, two way interactions between the independent variables and their relations to the learning outcomes were investigated. The test data were analyzed using the computer program Statistical Package for the Social Sciences (SPSS), sub-program Anova which provides a choice of multiple regression methods.

The .01 level of significance was chosen. The precise reason for the selection of this level of significance is provided in the thesis.

Only one significant effect for curriculum emerged. This was on the 'comprehension of science reading' scale where the non-ASEP group performed better than the ASEP group.

There was a significant difference in the performance of the sexes in that girls scored significantly better than boys on six of the seven scales.

For socio-economic status the only significant difference to emerge was on the 'library usage' scale where the higher socio-economic group performed better than the middle and low socio-economic groups.

There was a significant difference in the performance of the different school types on all seven scales with students from district schools scoring significantly below students from independent or high schools.

Significant two way interactions were observed between curriculum and school type on the 'charts and tables' and 'comprehension of science reading' scale. In particular the students of district schools performed better when ASEP materials were included in the curriculum. Another significant two way interaction between sex and school type emerged on the 'philosophical' scale. In particular on this scale the performance of girls was comparable, irrespective of whether they attended high school or independent school. However the boys from independent schools were superior to the boys from high schools.

CHAPTER I

INTRODUCTION

At the beginning of 1974 curriculum materials developed by the Australian Science Education Project were available for use in Tasmanian Secondary Schools. The ASEP materials consisted of units to be used in science classes from grade 7 to grade 10. From its inception one policy adhered to by the Australian Science Education Project was that it would be unwise for any school to use solely ASEP materials. The data gathered in this study indicate that this situation was the policy adopted by Tasmanian schools. The science curricula of many of these schools contain a mixture of ASEP and other materials.

This study examines the impact of the inclusion of ASEP materials into the science curriculum on cognitive outcomes. Grade 7 classes were chosen for the study as the pupils in these classes have almost identical backgrounds in science. Any differences that may be present are controlled for in the design of the experiment.

The variables investigated were sex, socio-economic status, school type and the use of ASEP materials. Information on cognitive outcomes was gathered using seven scales from the Test of Understanding Science (TOUS) and the Test of Enquiry Skills (TOES). These two tests

Science (TOUS), and the Test of Enquiry Skills (TOES). The TOUS test provided measures on three different outcomes on the understanding of science. These were named 'philosophical', 'historic-social', and 'normality of scientists'. The TOES test provided measures of four enquiry skills which were named 'library usage', 'scales', 'charts and tables', and 'comprehension of science reading'.

Following a pre and post-testing the data were interpreted using a multiple regression analysis. A full regression model was used separately for each of the seven outcomes. By this method the amount of variance in each of the seven post tests due to the curriculum used, over and above that due to the other independent variables and the pre-test, was estimated. In addition two way interactions between the independent variables and their relations to the learning outcomes were investigated.

CHAPTER II

THE AUSTRALIAN SCIENCE EDUCATION PROJECT

The Junior Secondary Science Project

The Junior Secondary Science Project was set up at the beginning of 1966, under the joint auspices of the Science Standing Committee of the Victorian Universities and Schools Examination Board and the Australian Council for Educational Research, to produce learning materials for grades 7 and 8 science in Victorian schools. The materials were subjected to extensive trials and, following subsequent revision, were made available in published form in 1968-9. The Australian Science Education Project originated largely from the interest generated by these curriculum materials.

The Australian Science Education Project (ASEP) was the first national curriculum project in Australia, and was sponsored jointly by the Commonwealth government and the six State governments. The initial funding was $1.2 million for a period of 4½ years, and the charter for the project was to develop instructional materials in science for grades 7 to 10 in secondary schools throughout Australia. The six State governments, through their curriculum authorities, formulated three principles on which ASEP was to be based:

1. The Project must produce a range of instructional materials sufficient in quantity to satisfy a major portion of the requirements for courses in secondary school science from grades 7 to 10.

2. The Project must take account of the similarities and differences in the present and projected pattern of science education in all States from grades 7 to 10.

> 3. *None of the States will prescribe the materials for the use in schools, or guarantee their use, in the belief that the use of the materials must arise from their quality. Each school should be free to choose what it considers to be the most suitable course, topic, method and approach to science.*
>
> *(ASEP Information Brochure 1)*

The project began in 1969 with a Committee of Management consisting of representatives from each state, a member from the Commonwealth government and a member of the Australian Council for Educational Research.

The initial impetus for the project was provided in January 1970 when a Guidelines Conference was held at Monash University, Melbourne. Forty-five people including representatives from school systems, scientists, educators and the initial members of ASEP had wide-ranging discussions to establish priorities and directions. The findings of this conference were published in Australian Science Education Project: Report of the Guidelines Conference, Monash University, January 1970. The conference was committed strongly to the outcome that ASEP should design science experiences which would contribute to the development of the child and that in these experiences the enquiry approach should predominate, resulting in individual and student group activities. It was also declared by the conference that teacher education and evaluation would play a major part in the success of ASEP.

The Aims of the Australian Science Education Project

One of the primary tasks performed by the project was the establishment of aims. The four aims written were expressed in terms of child behaviour and were intended to develop in children:

1. Some understanding of man, his physical and biological environment and his inter-personal relationship.

2. Skills and attitudes important for scientific investigation.

3. Some understanding of the nature, scope and limitations of science.

4. Some understanding of, and concern for, the consequences of science and technology.

(ASEP Document 35, 1970)

When the aims were amplified, it became clear that 'knowledge of most relevance' to children was to be favoured, and that abstract scientific concepts were to be regarded as less pertinent to children at the junior secondary level than some of the more practical aspects of science. Some of the skills, important for scientific investigation, listed by the Project were "observing, classifying, detecting relationships, formulating effectively". (ASEP Document 35, 1970). Relevant attitudes included those which predispose an individual "to demand evidence in support of claims, postpone judgement when evidence is inconclusive, seek rational explanations, prefer quantification, change opinions in the light of incompatible data, be persistent, be co-operative, be critically tolerant of others' opinions, represent observations honestly, admit to error, and take responsibility for actions'. (ASEP Document 35, 1970).

By achieving aim 3, the Project hoped to develop in children "some understanding of the principle of proposing and testing an hypothesis, and to have children realise that the laws and conceptual schemes of science change as scientific understanding changes, that *science advances through the use of the process of inquiry, that conventions which aid communication among scientists are standardized by international agreement, that scientists have varied allegiances and personalities, and that not all subjects are open to scientific investigation". (ASEP Document 35, 1970).*

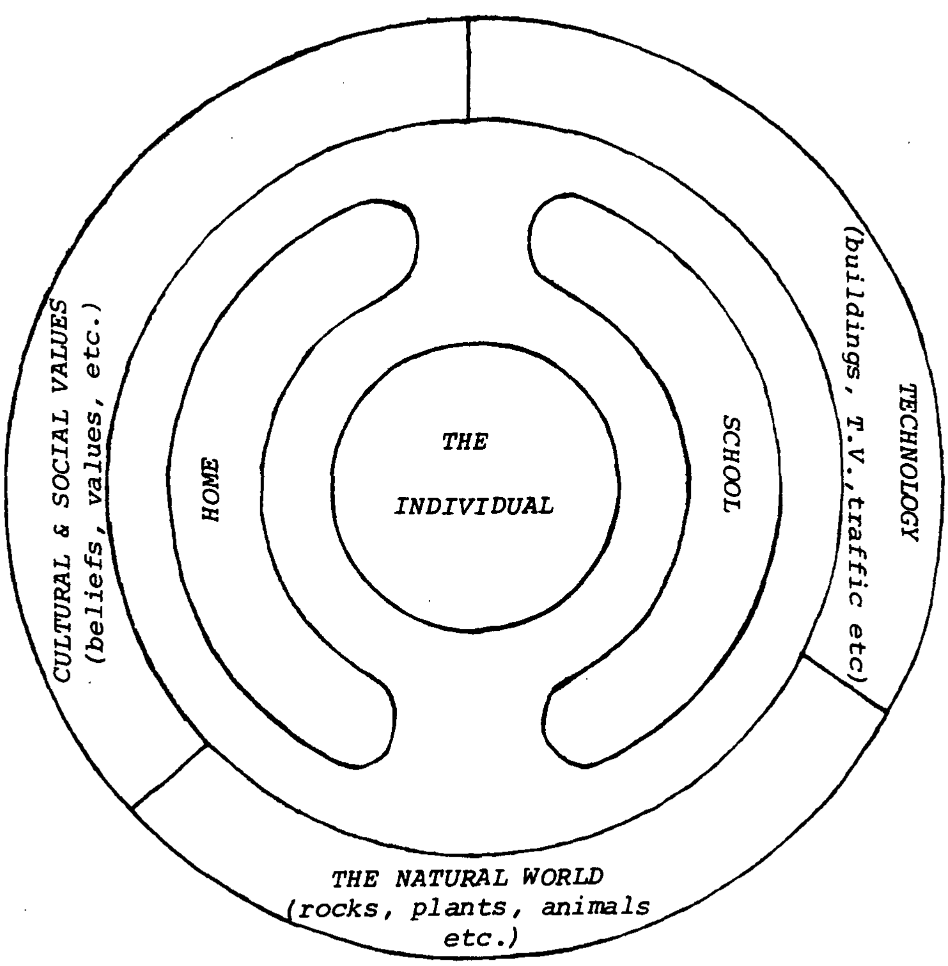
Through aim 4, the Project hoped to develop in children "some understanding of the way in which the findings of science have led to many technological advances which have contributed enormously to human welfare and civilizations but also a concern that, as a consequence of its impact on the environment, technology has given rise to problems concerning waste, the size of the human population, and general ecological change". (ASEP Document 35, 1970).

The Project includes two statements that are to be considered always in conjunction with these aims. These two statements are: 1. "The kind of understanding aimed at enables children to operate more effectively in their environment" and 2. "To arouse and foster the interest of children is of prime importance in the development of understanding skills and attitudes". (ASEP Document 35, 1970). A consideration of these aims indicates that ASEP was a project which emphasized the process aims of science rather than the content. This distinction is discussed in some detail in Chapter IV.

Ideas to be included

Following the determination of the aims, the next question to be answered was: "what science?". The two main sources for ideas were primarily the environment and secondly the nature of science. Of course ideas could have come from the content of science or the nature *of science but it was considered essential that a unifying theme should be chosen and this was the child's environment. Thus, the main source of ideas for inclusion in ASEP materials arose from consideration of the child's environment. The child's environment includes all the objects, forces and conditions, both internal and external, that affect the individual. The following diagram and its subsequent interpretation is presented by the author to clarify these interactions.*

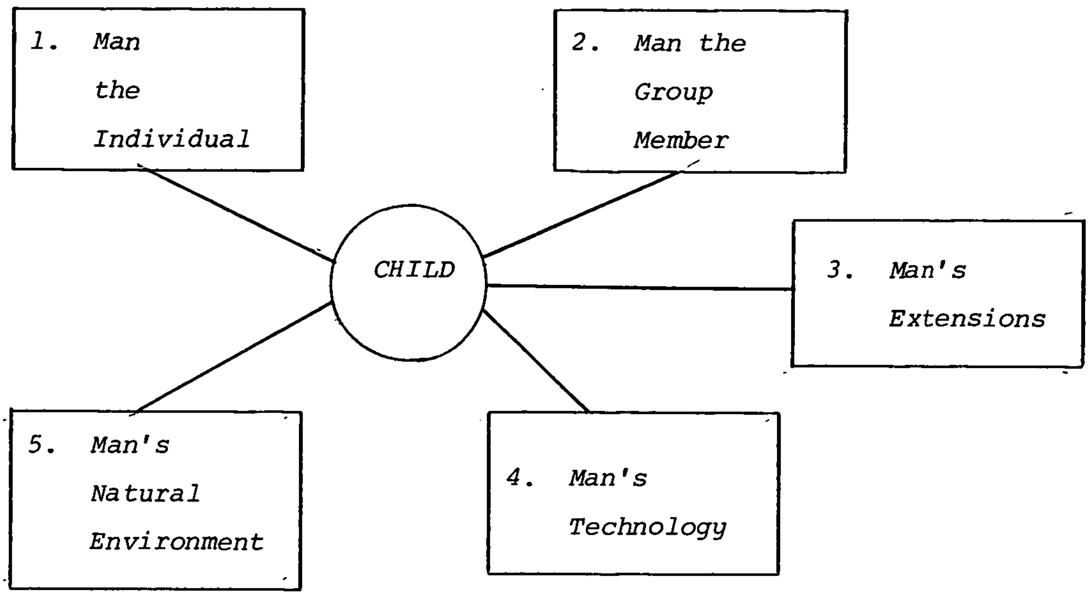
SOURCES OF STIMULI TO WHICH CHILDREN RESPOND



The various components of the environment are both overlapping and inter-dependent. The individual is influenced by his 'internal environment' and the school and home components determine largely what environmental stimuli the child receives. Quite often people referring to "the environment" or designing environmental courses consider only the one part of the diagram, i.e. the natural world. But ASEP considered the other important parts of the child's environment i.e. the technological environment of cities, traffic, television etc. and the environment of the society in which the child lives. In relation to the development of science materials, it was intended that the ideas would be presented to children in such a way that they would be seen by children as relevant to their present life and useful in helping them to gain an understanding of their environment. Emphasis would be given to the place of the child in his present environment, leading to an understanding that man is a living organism, who like other organisms, is continually interacting with his environment, yet whose interaction can be an interference with far reaching effects. The children should learn that a study of such interactions can lead to a better understanding of the environment.

ASEP's Environment Scheme was represented diagrammatically as follows:

<u>Figure 2</u>   *ASEP's Environment Scheme*



1. *Man must realize how he functions as an individual compared with how other living things function.*
2. *The role of groups in determining values and in making decisions concerning the use of the environment.*
3. *The ways in which man has increased his ability to learn about the environment and make use of it.*
4. *How technology has affected both man and his natural environment.*
5. *The changes that take place naturally and how these have been affected by the interference of man.*

(ASEP Document 36, 1970)

This environment scheme provided a coherent and logical framework, consistent with the aims of ASEP, and was used as the main reference source for ideas.

The second source of ideas was the nature of science itself as revealed by its history. The nature of science as described by ASEP includes the following points:

1. *Scientific knowledge consists of patterns (laws, generalizations, conventions etc.) created by scientists out of the phenomena of the universe.*

2. *The patterns, which change as scientific understanding changes, may be the result of planned investigation or conceived through insight.*

3. *One of the main methods of creating patterns is the use of experimental inquiry to look for constancy, for events that repeat. However the procedures of inquiry used by scientists follow no one clearly defined path.*

4. *Advances in science may take place by the interaction of theory and technology.*

5. *Modern scientific research, which currently involves more people than ever before, is costly and requires team work.*

(ASEP Document 36, 1970)

Again, the process rather than content nature of the materials was emphasized.

Selection Criteria

An idea to be developed in the science materials was selected usually from one of the two sources described previously. A suitable topic was chosen in which the idea could be developed. Then the selected topic was tested against eight criteria, which led to the acceptance or rejection of the topic.

The eight criteria used by ASEP are included below:

1. The ideas included lead to generalizations which enable children to see relationships that they may not otherwise have seen.

2. The ideas are meaningful to children in that they are related to direct experience.

3. The ideas are potentially interesting to children.

4. The activities of students contribute to the development of skills and abilities considered desirable.

5. Precedence is given to topics in which ideas considered to be more useful or important are developed.

6. The ideas included are generally able to be dealt with through student activity, preferably handling of apparatus and specimens; observation; use of references, photos, maps etc. and instructional devices such as audio-visuals, programs, and teaching machines.

7. Simple, readily available equipment and experimental situations are used where possible.

8. The ideas, activities and procedures involved are feasible. Here consideration is given to the abilities of children and teachers as we know them and the likely situation in schools in the immediate future in respect of equipment, finance and class organization. The stage of development of the children for whom a unit is intended will be one of the main bases for deciding the feasibility of that unit.

(ASEP Document 39, 1971)

The materials required some psychological framework that would take account of the individual differences between children. The traditional pattern had been to provide science materials for students grouped on an age-grade basis, but as the science materials were intended to contribute to the intellectual development of children it appeared to the Project to be better to establish the levels of the material against some researched ideas of intellectual development.

The use of Piaget's Theory

The selected scheme of intellectual development chosen by ASEP was that attributed to the Swiss psychologist Jean Piaget. Piaget describes the behaviour and abilities of children with respect to logical development and categorizes the intellectual development of children into three main stages. Piaget and Inhelder established age ranges for the stages with Geneva children as shown in Table 1.

TABLE 1: PIAGET'S STAGES OF INTELLECTUAL DEVELOPMENT AND AGE RANGE

STAGE OF INT. DEVELOPMENT			AGE RANGE
1	SENSORI-MOTOR		0 - 2 YEARS
	PRE-OPERATIONAL		3 - 6 YEARS
2	CONCRETE	2A	7 - 9 YEARS
		2B	9 - 11 YEARS
3	FORMAL	3A	11/12 - 14/15 YEARS
		3B	14/15 + YEARS

(Inhelder and Piaget, 1958)

Inhelder and Piaget distinguished two sub-stages in formal thinking. In the first sub-stage there is a large degree of thinking which is free from concrete props but formal thinking is not developed completely until the second sub-stage is reached. Because of this,and since unpublished research on Australian children suggests that they reach formal thinking at a later stage than the children tested in Geneva, the Project proposed to develop materials to suit children at three stages of development.

ASEP Stage 1 approximates to Piaget's concrete stage.

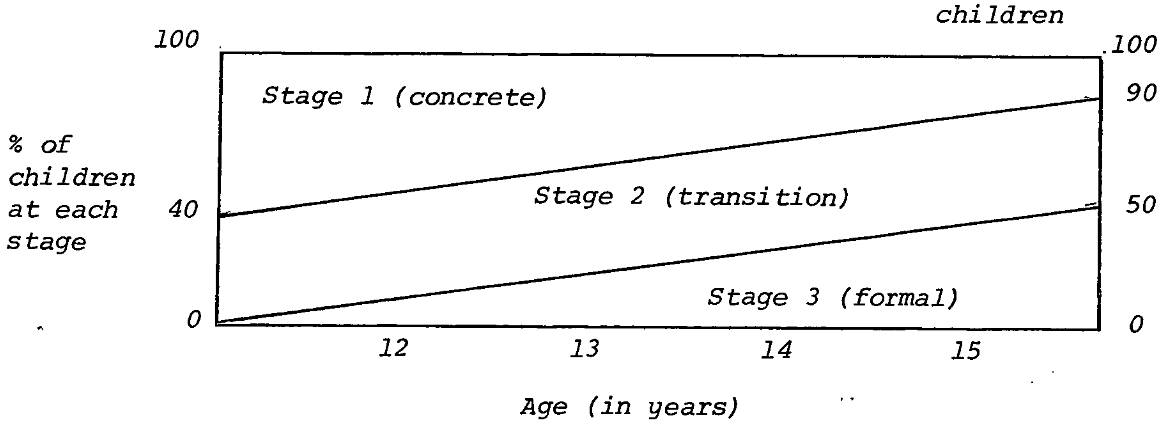
ASEP Stage 2 represents the transition between concrete and fully developed formal thinking and approximates to Piaget's first sub-stage - 3A - of formal thinking.

ASEP Stage 3 Approximates to Piaget's formal stage.

(ASEP Document 3, 1970)

The project assumed a pattern of change of stage with age derived from unpublished research by Dale.

Figure 3: Dale's* research on stages of development in Australian children



(Dale, 1970)

ASEP further used Piaget's theory of intellectual development in stating principles for dealing with subject matter. These principles, tabulated below, were based on those extracted from Piaget's theory by Ginsberg and Opper in 1969.

The following principles have been derived from Piaget's theory of mental development:

1. New ideas and knowledge should be presented at the level of the child's present thinking and language.

*DALE, L.G. was one of the Deputy Directors of the ASEP project and this influenced considerably the choice of Piaget's theory as an appropriate learning theory on which to base the development of the materials.

2. *A major source of learning is the activity of the child. Children must be able to try out things for themselves, to manipulate objects, words and symbols, ask questions, find their own answers, and discuss their findings with other children.*

3. *Classroom materials should be tailored to the needs of individuals and should present moderately novel situations. Children differ greatly in their levels of thinking, their approach to problems, their interests, and the time taken to accomplish tasks. Interest and learning are facilitated if the new experiences are moderately different from what is known.*

4. *Children should be given considerable control over their own learning. The normal child should be given a rich environment containing many things of potential interest.*

5. *Children learn by social interaction - children of all ages should be given opportunities to talk freely as part of their normal classroom activities and share their discoveries.*

(Ginsberg and Opper, 1969)

Enquiry Approach

One of the principles established at the Guidelines Conference was that ASEP should produce enquiry based materials. This was reflected in the aims and the choice of the Piagetian principles but ASEP assumed four other advantages of an enquiry approach in science teaching. They are:

1. *Active involvement is superior to passive reception in learning.*

2. *Learning occurs best when the situation stimulates without coercing and provides for success rather than failure.*

3. *Creativity is developed when the student is given opportunities to think creatively.*

4. *Enquiry can lead to the development of both critical and constructive attitudes".*

(ASEP Document 38, 1970)

Thus ASEP resolved to produce materials that encourage the enquiry approach and in the process develop in children skills and attitudes that enable an individual to enquire efficiently. That is, enquiry involves the individual in activities which require him to perform such skills as identifying problems, observing, measuring, classifying, ordering, inferring, predicting, formulating hypotheses, seaching for and discovering meaningful patterns, designing and performing experiments, interpreting and analysing the data, and verifying the validity of any conclusions reached. To use the enquiry approach the student needs to be involved actively in learning, to make some decisions, and to solve problems. Also the materials should involve a variety of approaches that enable students to practice the skills of enquiry, to think and be creative, and to see examples of how scientists have used enquiry in the past. For example in one unit students use problem solving skills to attempt to determine from where humans originated. In another unit students investigate the interrelationships among plants, animals and their surroundings in a bushland environment, and develop an understanding of ecosystems. In other units, students can read about the work of Robert Hooke, Robert Koch and Louis Pasteur.

The units and their formative evaluation process

It was determined by the Project that the materials would be developed as a number of units which would be separate entities but which could be combined with one another or with other materials to make a science course. The units thus would cover a variety of topics and include the science relevant to that topic and not be restricted to any one of the traditional science disciplines. The units would be prepared for each of the three stages of development described *previously,and be of varying length. Two significant trends in Australian science education prompted the decision to use this unit approach. One of these was the trend to use integrated science courses,and the second was the increased freedom being given to teachers to design and implement their own courses. Thus the ASEP units would add to the number of science materials from which teachers could select when constructing courses in science for the students at their own school.*

ASEP paid heed to the problem of readability of science materials when preparing the units by writing at a level,two gradesbelow that for which the units might be used. A modification of the Flesch readability procedure seemed the most appropriate and was selected to determine the reading levels of the written materials.

The development of a topic as a unit was initiated by a planning committee consisting of senior staff of the project. This committee decided which of the units suggested should be developed and who should write the first specification of the unit. This first specification included a statement on how the topic would contribute to the achievement of the aims of ASEP, the relationship of the topic to the ASEP environment scheme,and a general justification for the development of that particular topic as an ASEP unit. The first specification was evaluated by the senior staff of the project,and where necessary amended. A development team was formed consisting of a materials development officer (MDO) who had the responsibility of writing the unit, a research officer to assist in the preparation of testing materials and a discussant - usually the writer of the first specification - who assisted in the *planning of the unit. The MDO in consultation with the other two staff members wrote a second specification which included a plan of the unit in terms of a core which all students would study, and optional activities from which the students could select. This second specification was panelled and evaluated by members of the ASEP staff. Copies of the second specification were sent for evaluative comment, to each of the states and to subject experts. The plan was amended according to the comments received and the MDO then prepared the first draft of the manuscript. A rough manuscript was produced, and this was evaluated by a small group of staff members and outside subject experts.* After approval and editing, the MDO and the ASEP Head of Production designed the unit in terms of words, artwork, photographs and printing. All artwork and many of the photographs were provided by ASEP staff. The final material was printed and the unit was ready for its first trial. For the first trial, schools were selected in close proximity to ASEP headquarters to enable ASEP staff to observe the units being used in the schools. Eight volunteer trial teachers were allocated to each of the units.*

Different sources were used during this formative evaluation phase and included; the students of the trial classes, teachers of the trial classes; observations of ASEP staff, comments by subject experts and state advisory groups. All evaluative comments were collated and this feedback used to modify the original unit.

This same development procedure was used in the preparation of the unit for its national trial. The information to be gathered during the national trial was designed primarily to give evidence

**The overall scheme involved consultation with over a hundred subject experts. For example with the unit 'Plants' the Professor of Botany at Melbourne University, a C.S.I.R.O. algae expert and native plants experts were consulted.*

concerning changes to be made to the materials,in the light of classroom trials in all states. The three basic purposes for these national trials were; to ensure the validity of the materials for Australian schools; to provide a nucleus of teachers,experienced in ASEP philosophy and the use of ASEP materials,who would help with the introduction of the published materials in the various states; and to provide an opportunity for the different systems of education in the various states to evaluate the materials and, in particular, their relevance to local conditions. In a published document on national trials ASEP expanded these three basic purposes into eight which were:

1. *To determine the suitability of the various units in different classrooms.*
2. *To refine the content, structure and presentation of each unit based on evidence gained from the trials in the various states.*
3. *To explore different combinations and sequences of units and their effects.*
4. *To find out specific needs of the various states and to modify units where possible to account for these.*
5. *To establish or confirm necessary pre-requisites for teachers and students using a particular unit.*
6. *To determine sources of equipment and aids for the units in the various states.*
7. *To develop checklists and other supporting materials to help the teachers more effectively introduce ASEP units into schools.*
8. *To provide a group of teachers experienced in the use of ASEP units.*

(ASEP Document 59, 1971)

Following the national trial and the collation of the evaluative feedback,the cycle of development of units was repeated and the unit *prepared for its final publication.*

Thus ASEP achieved its aim of producing science units for grades 7 to 10 in Australian schools. Ultimately the Project produced forty one units for student use (sixteen units for stage 1; thirteen units for stage 2; twelve units for stage 3), six service units for use with the units, associated audio-visual materials, and one handbook describing the project and its materials. The units are variable but all contain a section known as the core which is completed by all students and occupies the student for about one quarter of the time spent on the unit. After completing the core students select from a number of options some of which are designed to extend the student intellectually while others provide less intellectually demanding or more concrete activities.

The main part of each ASEP unit is its student book, which is designed so that each student can work through it at his own pace. Other components include a teacher guide (incorporating the student book), and usually, a student record book. Some units include charts, cards and 35 mm transparency sets. The units are published in inspection packs, module packs and record packs. The inspection pack contains a teacher education and a record book (if there is one for the particular unit). The module pack contains ten student books, ten record books, and enough of all other prescribed material for ten students.

All materials are printed by the Victorian Government Printer, and distributed from the Education Department of Victoria Stores Branch direct to schools throughout Australia.

The national trials were an important agent of in-service training in the use of ASEP materials, and at their conclusion there were a number of moderately experienced teachers in Tasmanian schools. During 1973 seminars were held in the three regions of Tasmania and one representative from each school in the region was invited to attend the seminar. These seminars were designed to introduce teachers to the philosophy of ASEP, to the available units, possible methods of use, and to discuss any possible problems with teachers who participated in the national trials. The seminars were taken by the Tasmanian Supervisor of Science and the author who, at the time, was Consultant in Science. The teachers who attended the seminars were to become resource personnel for the methods of using ASEP materials within their own schools. The inservice training of teachers would be continued within the school. By this method, all schools were made familiar with the ASEP materials before the final published versions began arriving in schools in 1974.

Conclusion of the Project

The project terminated officially on March 31, 1974 and the following comments were written by the Director of the Project in the final newsletter before the termination.

> *The value of the materials produced cannot be proven until they have been used for some years. However, there are indications that various groups of evaluators already regard ASEP as a successful project. There is continuing interest from overseas educational bodies and this has resulted in invitations from UNESCO and ASEP staff members to take part in activities outside Australia. Major overseas publishers are eager to acquire rights for ASEP materials. The Australian Government has decided to continue assistance in curriculum development.*
>
> *In classrooms, it seems that ASEP materials have succeeded in providing for individual rates of progress, for decision-making by students, in*

> *integrating 'branches of science, in penetrating interdisciplinary barriers, and in helping some group-isolates to a better quality of human relationships.*
>
> *We believe that ASEP has already achieved success in at least four other areas. The most obvious, though possibly the least significant, has been the production of tested learning materials. We also believe that ASEP has had significant success as a focal point for educational discussions, whether within the headquarters, at conferences or in school staff-rooms. In addition, ASEP has provided training in many areas, not only for project staff members, but for trials teachers, working parties and research students. Last, but far from least, ASEP has established a pattern for accountability in education, at the highest level of which we have openly declared our aims and then submitted ourselves to public examination, cross-examination and judgement.*
>
> *(ASEP Newsletter No.5, 1974)*

The Australian Science Education Project did achieve its aim of producing science materials to be used by the children in grade 7 to grade 10 of Australian schools. A curriculum, in the normal sense, was not developed, as the deliberate policy was to develop materials that were made available to teachers. The teachers would have the freedom to design their own curricula incorporating ASEP units if they so desire. Teachers have the responsibility to decide on content aims to suit their own schools and then may select ASEP units to achieve these content aims.

CHAPTER III

EVALUATION AND THE EFFECTIVENESS OF ASEP MATERIALS

The Problem

The problem of the study undertaken was to determine how effective the inclusion of materials produced by the Australian Science Education Project was in Tasmanian schools. The ASEP materials have been introduced recently into Tasmanian secondary schools and because of their wide-spread use the effectiveness of the materials requires determination. Furthermore Westbury states

> *A curriculum must be understood on its own terms before being evaluated in other terms*
>
> *(Westbury, 1970, 253)*

The author was a member of the ASEP Project team and thus fulfilled this requirement.

The problem was one of curriculum evaluation and initially it was necessary to justify the need to carry out such an evaluation. During the developmental stages of the project the materials were evaluated continually and Cronbach writes

> *Evaluation used to improve the course while it is still fluid, contributes more to improvement of education than evaluation used to appriase a product already placed on the market.*
>
> *(Cronbach, 1963,236)*

Scriven on the other hand sees the importance of having both ongoing evaluation during the developmental stages of a curriculum and evaluation on completion of the curriculum.

> *Educational projects, particularly curricular ones, clearly must attempt to make best use of evaluation in both these roles*
>
> *(Scriven, 1967,43)*

For the former type Scriven introduced the term formative and for the latter the term summative. These terms are defined briefly by Mackay in a paper presented at the Annual Conference of the Science Teachers Association of Tasmania in Hobart in 1975.

> *Formative evaluation is conducted as an ongoing process during the course of a unit of instruction. Its primary purpose is to provide feedback to pupils and instructor on the effectiveness of instruction as the pupils progress through the instructional sequence. By providing continual monitoring of the degree of mastery of given learning tasks, formative evaluation can help both instructor and pupil focus attention on these particular aspects of the learning task which have not yet been mastered.*
>
> *Summative evaluation is conducted at the end of a unit of instruction, or at the end of some substantial part of it, and is directed towards a general assessment of the degree to which the ultimate objectives of a unit of instruction have been mastered. An essential feature of summative evaluation is that some judgement is made about the pupil, the instructor, the instructional procedures or the curriculum materials with regard to the effectiveness of the learning that has occurred, and that this judgement occurs after the instruction concerned has taken place. Thus summative evaluation is essentially an after-the-fact affair, and the pupil seldom has the opportunity to study the material in the unit further as part of the current instructional sequence.*
>
> *(Mackay, 1975,10)*

No doubt Cronbach is correct in emphasising the importance of formative evaluation. However with more and more curriculum materials being made available for science teachers, and in particular with the freedom within the new Tasmanian science syllabus, teachers are forced to make decisions about certain science curriculum materials. Information is required to aid this decision making process, and it follows that summative evaluation evidence should be provided to the users of the curriculum. Support for this belief can be found in the literature on curriculum evaluation. For example Glass, while acknowledging that considerable funds have been devoted to the development of curriculum projects in science at all levels comments that

> *only an infinitesimal fraction of the cost is designated for evaluation.*
>
> *(Glass, 1972,108)*

Lehman supports Glass's contention and writes

> *The demand and need for evaluation of the "new" curriculum programs in science and mathematics (BSCS, CHEMS, CBA, PSSC, SMSG, ESCP etc.) has been recognized from the time the studies began. Yet relatively little effective evaluation, aside from teacher feedback and certain testing programs organized by the respective curriculum developers, has taken place*
>
> *(Lehman, 1967,21)*

In discussing the products of curriculum projects Saadeh believes

> *there is not enough data to show that the results match the generous money and effort involved*
>
> *(Saadeh, 1973,248)*

while Herron contends

> *it appears that the problems associated with making changes in school systems are small in comparison to the problems of finding out whether these changes, once made, make a*

> *difference in variable which we deem important*
>
> (Herron, 1971,159)

There are a number of suggestions in the various papers on this subject describing the methods that may be employed in evaluating a curriculum. Cohen describes how curriculum evaluation is concerned

> *with providing sets of judgements on how good a curriculum is - the value of the curriculum for selected purposes*
>
> (Cohen, 1973,34)

Metfessel and Michael,(1967),identify 105 criteria that might be chosen for judging effectiveness and Scriven, (1967), also has written extensively on methods of curriculum evaluation. Welch in one of his articles suggests that several different avenues are open in assessing the impact of national curriculum project. He cites three examples:

> (1) *by determining the degree of achievement of stated objectives*
>
> (2) *by determining their contribution to general educational objectives*
>
> (3) *by determining the degree to which the course is accepted and used in schools.*
>
> (Welch, 1968,225)

This third aspect cited by Welch has been the subject of an evaluation and report by Owen and by Fisher and Fraser. In 1975 Owen collected data from a random sample of schools throughout the country and forty Tasmanian schools were included. Thirty three schools responded and Owen determined that approximately nine out of ten schools had purchased some module pack of ASEP materials. Owen corrected his figures for school size and determined the average state purchase of

ASEP module packs over time per 500 science students. Tasmania formed a high buying group with 70.4 module packs per 500 students being purchased prior to February 1976.

Furthermore Owen tabulated the mean school use of ASEP in 1975 by year level and the following table illustrates his figures for Tasmania.

TABLE 2: MEAN SCHOOL USE OF ASEP

School Year	Proportion of Year in which ASEP materials are used
Year 7	.78
Year 8	.79
Year 9	.75
Year 10	.53

(Owen, 1977,52)

Owne's results would suggest that ASEP materials have been accepted and used in Tasmanian secondary schools.

Fisher and Fraser surveyed, earlier in 1973 during the national trials, the impact of ASEP materials on teachers. Twenty seven of thirty high schools and eleven out of twenty one district schools were included in the survey. Amongst the replies to questions provided by teachers the answers to two, tabulated below, are of particular significance.

1. *In what grades would you use ASEP in future years?*

TABLE 3: PERCENTAGE OF TEACHERS WHO WOULD USE ASEP

Grade	Percentage of teachers who would use ASEP
7	94.7%
8	97.4%
9	94.7%
10	73.6%

(Fisher and Fraser, 1974,94)

2. *For what percentage of the science curriculum would you use ASEP materials?*

TABLE 4: MEAN USE OF ASEP PER GRADE

Grade	Mean use for grade
7	.51
8	.48
9	.42
10	.31

(Fisher and Fraser, 1974,94)

The results of the survey carried out by Fisher and Fraser are supported by Owen's results. Both surveys suggest that ASEP materials have been accepted, at least initially, into Tasmanian schools.

This study was concerned more with Welch's first two points i.e. that the impact of the project can be determined by the degree of achievement of its stated objectives and by its contribution to general education objectives. This method is supported by Mackay who writes specifically on the curriculum evaluation for science courses.

> *Summative evaluation is conducted at the end of a unit of instruction, or at the end of some substantial part of it, and is directed towards a general assessment of the degree to which the ultimate objectives of a unit of instruction have been mastered.*
>
> *(Mackay, 1973,11)*

This comment also suggests that one way of determining the effectiveness of materials is to measure the achievement of the objectives. Mackay goes on to list the contributions that summative evaluation can make to the process of instruction, and shows how this process can be used to good effect by classroom teachers.

For reasons of economy and feasibility the study is confined to Tasmania but in Musgrave's recent publication "Contemporary Studies in the Curriculum" Mackay writes generally about curriculum evaluation.

> *In an educational system in which the decision to introduce a new curriculum means that the innovation occurs in all schools in the system, evaluation will be primarily concerned with evaluating the effectiveness of an innovation after the innovation has been implemented. Feasibility studies designed to measure the likelihood of success of proposed innovations when applied to a broader context, or formative evaluation studies intended to assist in the pre-adoption development of a curriculum innovation, have little direct applicability in such contexts.*

> *The focus of evaluation studies will be on summative evaluation of the effectiveness of an innovation in a particular educational system, which will have attributes which distinguish it from all others. Consequently, the generalizability of results of these studies to other educational systems or other educational contexts is almost certainly strictly limited.*
>
> *(Mackay, 1974,216)*

Assuming that a curriculum evaluation is worthwhile and necessary then curriculum evaluation models can be used to indicate the variables that should be included in the evaluation. In the case of all curriculum evaluation models it is obvious that Welch's first two points are supported, in that the achievement of objectives is regarded of prime importance by all writers. Models devised by Metfessel and Michael (1967), Hughes (1973), Taylor and Maguire (1966) and Stufflebeam (1966) have this notion as a central consideration.

Robert Stake states that curriculum evaluation requires

> *collection, processing and interpretation of data pertaining to an educational program*
>
> *(Stake, 1967,5)*

He goes on to say that for a complete evaluation two kinds of data must be collected. (1) Objective descriptions of goals, environments, personnel, methods and content, and outcomes and (2) personal judgements as to the quality and appropriateness of those goals, environments etc.

Stake sees the curriculum evaluator as having a number of tasks. He lists these as:

> *weighing the outcomes of a training institute against previously stated objectives; comparing the costs of two courses of study; collecting judgements of the social worth of a certain goal; determining the skill or sophistication needed for students commencing a certain scholastic experience*
>
> *(Stake, 1967,5)*

Curriculum evaluation involves some judgement after a set of measures or observation is compared with a set of criteria. This means estimating the extent of matching between the set of measures and the set of criteria. Stake refers to this as a 'principle of congruence'.

Stake realises the importance of judgements in the evaluation and suggests two possible cases for judgement. If a relative standard is employed, the criterion becomes the outcomes of another curriculum, or some control group (Stake refers to this briefly in comparing the costs of two curricula). Although Stake does not use the term this is actually Scriven's 'summative evaluation' procedure. The second possible basis for judgement is an absolute standard which usually includes the intended outcomes or objectives of the curriculum. This includes objectives relating to student behaviour, attitudes, methods adopted by teachers, use of aids in the classroom etc. Most often this kind of evaluation will include a feedback loop since knowing the extend to which objectives have been obtained, modifications can be made when necessary. This of course is Scriven's "formative evaluation". Stake suggests therefore that there are other variables *that should be considered in a curriculum evaluation other than the cognitive outcomes of the curriculum.*

Stake's model for curriculum evaluation can be considered at three levels labelled antecedents, transactions and outcomes.

"Antecedents" include entering behaviours of students that refer to conditions existing prior to the introduction of the curriculum. They may also include motivations of students, equipment and aids available etc. "Transactions" refer to what happens in classrooms, laboratories etc. that directly relate to the curriculum. Outcomes include student achievement, attitude, activities required by teachers and any changes in the antecedents. At each of the three levels it is possible to compare the kinds of things 'intended' to happen with the kinds of 'observations' of what actually happened.

Although Stake's model appears to be more applicable to the formative evaluation of materials it nevertheless suggests that variables other than outcomes like student achievement should be included in any curriculum evaluation.

Welch and Walberg in an article define evaluation as those activities which

> *provide information useful in course improvement, and which show how effective the course is under specified school conditions. In addition we recognise the responsibility and opportunities available in a large scale curriculum evaluation for carrying out research on problems of science education.*

(Welch and Walberg, 1968,10)

Later Walberg developed a model for curriculum evaluation. The paper he writes is

> *an attempt to show that much of the reliable variance in student performance is attributable to the aptitude of the learner and the environment of learning, leaving only a small part to be accounted for by instructional variables and perhaps by interaction between the three factors*
>
> *(Walberg, 1970,185)*

He also writes in the same article

> *Thus in formulating models for research or instruction, estimates of aptitudes and learning environments should be included because they account for substantial variance in learning criteria. Such models have several advantages: They would allow a determination of the relative effects of design factors; they would increase the precision and power of the analysis; and they would permit an investigation of the interactions of the factors*
>
> *(Walberg, 1970,187)*

Walberg's model can be abbreviated and expressed as

$$L_h = f\ (I_i,\ A_j,\ E_K) \qquad \text{(Walberg, 1970,187)}$$

where L_h *stands for the set of learning outcomes,* I_i *for the instruction,* A_j *for the aptitudinal and personological attributes of the pupil and* E_K *for the learning environment.*

Walberg's model is useful when considering which variables to include in the evaluation of the impact of ASEP materials. If the model is applied to the evaluation of ASEP materials then the L_h *term becomes the measure of the outcomes most pertinent in an ASEP evaluation.*

The I_i terms of Walberg's model is taken to represent whether a student belonged to a class which used ASEP materials, i.e. ASEP units were included in the science courses during the year, or a class in which ASEP materials were not used. The philosophy behind the use of ASEP materials have been discussed in Chapter II.

Walberg suggests that student aptitudes should be included and these are similar to the antecedents suggested by Stake.

Walberg defines aptitudes as

> characteristics of the individual or his experience that predict a given learning criterion.
>
> (Walberg, 1970,185)

Messick supports the idea of looking at student aptitudes when he writes

> to evaluate educational treatments in terms of their effects upon individual pupils requires not only the assessment of variables directly related to specific goals of the treatment, such as achievement level, but also the assessment of those personal and environment variables that may moderate the learning.
>
> (Messick, 1972,49)

A review of the literature indicates that sex and socio-economic status are aptitudinal variables influencing consistently the learning outcomes of students.

Meyer (1961, 1963) reported the results of surveys he conducted in England and in Australia where he showed that there was a strong sex bias preference towards either the physical or biological sciences.

He came to the conclusion that this was largely of historical origin. Meyer also found that a pupil's interest in science is related closely towards his performance in the subject.

Another major study in the area of sex differences has been carried out by Rowlands (1961) who studied the factors leading towards the choice of science as a career. In this research he showed that the home environment played an important part in the selection of science for a career. Pheasant (1961) carried out similar research and his conclusions supported those of Rowlands.

Grobman (1968) in an extensive study, Lisonbee and Fullerton (1964), Lance (1964), and Lewis (1962) in smaller studies, compared versions of the B.S.C.S. course with the traditional biology course. Apart from discovering that in general B.S.C.S. students scored higher on B.S.C.S. comprehensive tests while there was little difference between B.S.C.S. and traditional course students on traditional tests, they also showed that in general there was a sex difference with boys outscoring girls.

Rowell (1971) researched the 'Sex Differences in Achievement in Science and the Expectations of Teachers'. He says that

> *there are considerable bodies of evidence for the existence of differential social pressures and also for differences in intellectual functioning of the two sexes.*
>
> *(Rowell, 1971,17)*

The main conclusion that Rowell came to was that boys generally achieve higher marks in science examinations than girls where the expectations of the teacher influence the class.

Hughes (1973) following an investigation of the achievement of Grade 7 students after teacher reacting variables and student responding variables were experimentally manipulated noted that there was a clear sex difference in favour of boys in one of his experiments.

Ogunyemi (1973) while investigating the relationship between science achievement level and cognitive style discovered that there was a significant relationship between the two variables for the boys but not the girls.

The variable sex was included in this study and during the testing phase data were gathered on the sex of the participating students. The students were asked to write at the top of their response sheets whether they were a boy or a girl.

The second variable investigated was socio-economic status. Data gathered previously for the Fisher, Fraser study in 1974 supported the contention that this variable should be included. Writers such as Asbury (1973) have also found that there are significant differences between different socio-economic groups. Socio-economic status was determined by using the Status Ranking List of Occupations in Australia, a device constructed by A.A. Congalton in 1969. Using the occupational and educational status of the father, this instrument locates an individual's social class position in a scaled continuum of seven classes ranging from class 7 as the lowest to class I as the highest position in the scale. Thus each student was asked to record his father's occupation on the response sheet and then assigned a scaled social position score which corresponded to one of the specific social classes. This seven point scale is later reduced to a three point scale for analysis purposes. Categories 1 to 4 formed a high socio-economic group, category 5 forms a medium group, and categories 6 and 7 the low group.

The third variable of Walberg's model is learning environment and Walberg defines learning environment as

> stimuli, aside from deliberate instruction, that predict a learning criterion.
>
> (Walberg, 1970,185)

Bloom suggested that in evaluation studies the environment (instruction, class or school) is assumed to be a major source of behavioural changes. He goes on to write

> Therefore, evaluation should be as much concerned with the characteristics of the environment which produce the changes in student behaviour as it is with the appraisal of the changes themselves.
>
> (Bloom, 1966)

Baker adds to this

> This position certainly suggests that in evaluation activities considerable attention must be paid to specifying environmental conditions that interact in producting the payoff response of interest.
>
> (Baker, 1969,347)

Walberg has written considerably about the role of the learning environment curriculum evaluation. Included in his writing he notes *that*

> *Perhaps a more fruitful area of optimization and sub-optimization research lies in the social environment of learning brought about by different courses. Exploratory research has already shown significant differences in environments attributable to randomly assigned courses. Moreover with relevant factors held constant, the social environment is an optimizer of cognitive and affective learning; and environmental characteristics sub-optimize student learning, i.e. students of different levels of intelligence, personality, and other characteristics differ sharply in their performance in different environments.*
>
> *(Walberg, 1970,563)*

There is considerable support in the literature for Walberg's contention that the learning environment should be included in any curriculum evaluation and this belief is held by the author, but it was beyond the scope of the present study to gather data on learning environments as defined by Walberg. Nevertheless data were included on the type of school attended by the student and it could be argued that school type is in some way an environment variable. There are three types of secondary schools in Tasmania. Schools which have students in grades 7 to 10 only are termed High Schools while those with students in grades from Kindergarten to grade 10 are called District Schools. Both schools are administered by the Tasmanian Education Department. District schools are situated in the country areas of Tasmania and usually there is a High school situated in a neighbouring town. Many of the children of higher abilities leave the District school at the conclusion of grade 6 to attend the neighbouring high school. Thus there is a depletion of numbers in the District school and consequently a depletion in teaching staff and variety of curriculum. Behrens (1977) has produced data (discussed in more detail *on page 88) that shows that the children of these District schools are a deprived group. The third type of school belongs to the independent system. These schools are usually church schools with their own councils and functioning independently of the state education authority. The students from these schools formed the third category of the variable school type.*

Another reason for including the variables of sex, socio-economic status and school in addition to the curriculum variable is that they provide statistical control for relevant variables that also influence learning. The improvement or otherwise in learning due to the inclusion of ASEP materials is measured after the effect of these other variables has been removed. The inclusion of the variables chosen also allows the the examination of the different effectiveness of the inclusion of ASEP materials for different students in different schools.

It was the intention of the author that the variable general ability (I.Q.) should also be included in the study. However when requested the majority of schools involved refused to divulge information on the I.Q. measurements of their students. The data obtained was from a sample so small as to be meaningless and had to be removed from the analysis. In a previous study reported in 1974 the author showed that ASEP materials were more effective for pupils of high I.Q. than those of low I.Q. However the enforced deletion of the variable in this study should be borne in mind when the results are interpreted.

CHAPTER IV

METHODOLOGY

Selection of Experimental Design

Effective materials can be defined as those that lead to the attainment of certain objectives. Thus there should be observable changes in the students who use the material being evaluated, in that they will show significant gains that can be measured by improved performance on a pre-post test situation. The students with ASEP materials included in their science curriculum are compared with those using traditional methods or other methods. <u>If the ASEP materials are really effective then the curriculum in which they are included should be significantly better than the other curriculum that attempts to achieve the same objectives</u>. These are the objectives important in junior secondary science. The experimental design selected for the evaluation is the Campbell and Stanley "Pre test-Post test Control Group Design" with students being assigned to the groups through the sampling process described later.

$O_1 \quad X \quad O_2$ *

$O_3 \quad X \quad O_4$

(Campbell and Stanley, 1963)

This design controls most of the sources of invalidity recognized by Campbell and Stanley. 'History' (i.e. the specific events occurring between the first and second measurement other than the instruction) is

* O_1 and O_3 = pre test

O_2 and O_4 = post test

X = experimental treatment

controlled by the comparison of the two groups (O_4 and O_2). The problem of 'maturation' (i.e. any growth in the students, e.g. growing older), is controlled for by comparing the same two groups. One would expect maturation and history effects to occur approximately equally in the two groups. As the instruments to be chosen are assessed objectively by the one evaluation, instrumentation, which is the term described by Campbell and Stanleyas the autonomous changes in the instrument used for measuring changes, is not a source of invalidity. 'Statistical regression' should not affect the results as the groups have not been selected on the basis of extreme scores and it can be assumed that the groups are very similar in entry behaviour having been chosen from the population of grade 7 students in Tasmania. Furthermore the two groups were checked for any statistical difference during the pre-test. The source of invalidity described by Campbell and Stanley as 'mortality' and defined as the 'loss of respondents from the comparison group' is not a problem with two large groups.

Application of Chosen Design

The selection of subjects for the experimental and control groups was carried out in the following way. At the beginning of the school year a letter was sent to every school in Tasmania that contained secondary classes. The number of Principals of these schools to receive the letter was fifty-eight. The letter explained that an evaluation of the effectiveness of ASEP materials was to be carried out and the co-operation of schools throughout the state and in particular the teachers of grade 7 was requested. It was emphasized that the evaluation would require only about three hours of class time during the whole year and that a pre-test would be given in March to be followed by a post-test late in the year. All testing materials were to be supplied. Further it was stated that *two types of classes were required, those using ASEP materials and those who were not using any ASEP materials. Thirty seven schools responded to the request. Four schools declined to take place in the evaluation and the other thirty three indicated their willingness to take part. This gave a response rate of 56.9%. The responding schools could be categorized as high schools (schools with grades 7 to 10 only); independent schools; and district schools (schools with grades 1 to 10).*

TABLE 5: PARTICIPATING SCHOOLS

HIGH	INDEPENDENT	DISTRICT
Rose Bay	Fahan	Exeter
Geilston Bay	St. Marys	Beaconsfield
Clarence	Hutchins	Rosebery
Claremont	Sacred Heart	King Island
Rosetta	St. Thomas More's	Oatlands
Taroona	Marist College	Campbell Town
Queechy		
Kings Meadows		
Riverside		
Deloraine		
George Town		
Scottsdale		
Wynyard		
Devonport		
Reece		
Ulverstone		
Latrobe		
Murray		

Three schools that participated in the pre-testing failed to complete the post-test.

The population for the study was the students of grade 7 in Tasmanian schools. This total population was reduced by the lack of response from some schools. The size of the population was reduced further when students moved from one class to another, or left the school, or were absent from school on the date of the post-testing. Thus there was an attempt to include the total population but administrative factors determined the ultimate sample.

Grade 7 was selected because it is the first year of the secondary system and since ASEP materials have been designed for children of grades 7 to 10 students would be exposed initially to ASEP in their grade 7 year.

The numbers of students who participated in the experiment i.e. those who completed two pre-tests and two post-tests are indicated in table 6.

TABLE 6: MEAN USE OF ASEP PER GRADE

Type of School	*No. of Students Participating*
High	*1859*
District	*154*
Independent	*360*
TOTAL	*2373*

As it is part of ASEP philosophy that teachers select which science materials to use, no interference was made with the curriculum of the participating schools, and they were free to decide whether to use ASEP materials or not. The possibility was there to supplement the use of ASEP materials with other materials. In fact the percentage of time spent on ASEP materials, in the classes defined as ASEP classes, varied from 20% to 60%. The mean value was approximately 40%. The classes defined as control classes had no experience of ASEP materials at all.

The numbers of students that constituted each group are shown in Table 7.

TABLE 7: STUDENT NUMBERS

ASEP	1728
NON ASEP	645

When further categorized into school groups the numbers in the sample are shown in Table 8.

TABLE 8: SAMPLE CATEGORIZED INTO SCHOOL TYPES

SCHOOL TYPE	ASEP	NON ASEP
HIGH	1529	330
DISTRICT	52	102
INDEPENDENT	147	213

The testing materials were distributed to the schools during March and each student in the grade 7 class in the schools completed both the Test of Understanding Science and the Test of Enquiry Skills. The following instructions were given to the supervising teachers.

1. Would you please ensure that students write their name, whether they are a boy or a girl, and their father's occupation at the top of each of the response sheets.
2. The tests are to be given in the order: first, Test of Understanding Science; second, Test of Enquiry Skills.
3. Would you give students time to complete each of the tests.
4. Please request that students do not write on the question paper.

The tests were distributed to the same group of schools in November with similar instructions to the teachers and the data for the post-test were collected. This methodological design has been used frequently in curriculum evaluation, and proved successful in the pilot run reported by Fisher and Fraser in 1974.

Selection of Instruments

One of the chief aims of ASEP is that children should develop an understanding of science. If this is an important aim in science then it should be considered by science writers as a worthwhile objective.

Kimball writes that

> one of the most commonly stated objectives for science education is the attainment of an understanding of the nature of science.
>
> (Kimball, 1968,110)

Robinson observes that

> The challenge to science education is to bring to the full range of young people a comprehension of the nature of science as a human enterprise.
>
> (Robinson, 1969)

In addition Cooley and Klopfer write:

> One of the pervading themes among the generally recognized objectives for science instruction in the schools is the attainment of realistic understandings about science and scientists.
>
> (Cooley and Klopfer, 1963,33)

Mackay comments on the agreement among science courses on the objectives of teaching science and compares this with teaching methods and content

> Although there is no general agreement on which particular generalizations and principles are to be included in contemporary science courses, or on the methods of instruction to be employed, there is a good measure of agreement on the objectives of teaching science.
>
> (Mackay, 1970,57)

Klopfer categorized student behaviours which may be sought as outcomes of science instruction in secondary schools. The main focus of his scheme is on the categories of student behaviours related to carrying out the processes of scientific inquiry. Klopfer writes

> This focus is justified, not only because the contemporary trend of science education is towards an emphasis on the processes of inquiry, but because science is meaningfully and significantly considered as a system of inquiry, rather than simply as structured knowledge.
>
> (Klopfer 1971, 566)

There are nine major categories in this classification by Klopfer. Other statements exist in the literature on what the important aims of science education are. Fraser in Science Education Research 1974 reviewed the statements of one hundred and seventeen different authors (experts) and collected 1509 objectives. As a result of this review Fraser added two more categories to Klopfer's scheme and published the following table.

Table 9: CONSENSUS OF EXPERT OPINION ON THE IMPORTANCE OF AIMS IN THE MODIFIED KLOPFER CLASSIFICATION

Category	Title of Category	Authors Number	Authors Proportion	Objectives Number	Objectives Proportion
A.O.	Knowledge and comprehension	71	0.61	135	0.09
B.O.	Processes of scientific inquiry 1; Observing and measuring	62	0.53	156	1.10
C.O.	Processes of scientific inquiry 11; Seeing a problem and seeking ways to solve it	57	0.49	168	0.11
D.O.	Processes of scientific inquiry III: Interpreting data and formulating generalizations	71	0.61	224	0.14
E.O.	Processes of scientific inquiry IV; Building, testing and revising a theoretical model	18	0.15	25	0.02
F.O.	Application of scientific knowledge and methods	53	0.45	83	0.05
G.O.	Manual Skills	21	0.18	26	0.02
H.O.	Attitudes and interests	87	0.74	276	0.18
I.O.	Orientation (Includes philosophical, historical and social aspects of science)	83	0.71	329	0.21
L.O.*	Processes of scientific inquiry V: Using the Literature	41	0.35	80	0.05
S.O.*	Cognitive styles (Includes creativity and cognitive preferences)	8	0.06	7	0.00

* These categories have been added to Klopfer's original scheme.

(Klopfer, 1971,562,563; Fraser, 1974,101)

On applying this scheme to the evaluation of the effectiveness of ASEP materials in Tasmania it was decided to delete Klopfer's categories A.O. and F.O. because as described previously there is no common area of knowledge acquired by students using these materials. There is always a problem in evaluating attitudes and interests in that only the student's opinion is being recorded and one is not sure whether this expresses his/her true attitude or not. For this reason and for the constraints of time the category H.O. was deleted also.

It was decided therefore to concentrate in this study on the evaluation of the processes of scientific enquiry and on understanding of science. These are generally agreed to be worthwhile aims of science and also are included in the aims of ASEP quoted in Chapter II.

Instruments to evaluate these objectives then had to be selected. Cooley and Klopfer emphasize the importance of this step in any research.

> *The selection of appropriate evaluation instruments is probably the most crucial aspect of research and development in the areas of curriculum and methods. In spite of this, tests are usually chosen for educational experiments in far too cavalier a fashion.*
>
> *(Cooley and Klopfer, 1963,73)*

They add further that

> *In conducting developmental research which inquires into the effects of new methods, we must include, as an integral part of that research, the selection or design of the testing instruments which will best evaluate those specific objectives.*
>
> *(Cooley and Klopfer, 1963,73)*

Test of Understanding Science

It was decided to investigate the possibility of using the Test *of Understanding Science (TOUS) as one of the instruments in the evaluation. Klopfer and Cooley listed areas and themes which were identified as important components of an understanding of science and scientists. They acknowledge the consultative assistance of a number of scientists, science educators and philosophers of science. The themes determined by Cooley and Klopfer were grouped into three significant areas. These were:*

AREA I	*Understanding about the scientific enterprise*
AREA II	*Understanding about scientists*
AREA III	*Understanding about the methods and aims of science*

(Cooley and Klopfer, 1963, 74)

The first area concerned such aspects as the human element in science, the interaction between science and society and communication between science and society and communication between scientists. The second area contained generalizations about scientists as normal people while the third area was concerned with the aims of science, theories, models and scientific methods.

Cooley and Klopfer developed an original pool of two hundred multiple choice questions based upon the identified themes. They noted that

> *The general principle underlying the construction of items was that, if a student understood the ideas expressed in a theme or several connected themes, he would be expected to select the best answer from the alternatives presented.*
>
> *(Cooley and Klopfer, 1963,74)*

These questions were edited, reworded, revised or rejected and after *this process one hundred and twenty items remained. These items were criticized as to content validity, appropriateness, and clarity by consultants at Harvard University and other institutions. The remaining items became the first form (Form Z) of TOUS and this test was given to one hundred high school students. After item analysis Form Y was trialled and then Form X containing sixty four items was given to 3,000 students in one hundred and eight high schools as part of the History of Science Cases Instruction Project. In this project Klopfer developed a series of History of Science cases for High Schools (H.O.S.C.). The purpose of this study was to evaluate the effectiveness of the H.O.S.C. instruction method in changing student understanding of science. He compared students who studied H.O.S.C. with those who did not, using the instrument TOUS. He concluded that*

> *There are indeed significant differences in understanding of science and scientists between students who have studied under H.O.S.C. and those who have not. H.O.S.C. is definitely effective in increasing student understanding of science and scientists.*
>
> *(Klopfer and Cooley, 1963,46)*

One further important observation made by Klopfer was that the so-called intangible objectives of science instructions could be measured and he records:

> *Finally this study has illustrated that the so-called "intangible" objectives of science instruction <u>can</u> be measured and that, with the expenditure of relatively little class time and through the use of instructional materials specifically designed for this purpose, significant student gains in these important understandings can be achieved.*
>
> *(Klopfer and Cooley, 1963,46)*

Klopfer (1969) also 'used' a TOUS instrument to evaluate the Astronomy materials of the Earth Sciences Secondary Project. This instrument was Form Ex and contained thirty six items. Klopfer reported a reliability of .58 ($K\text{-}R_{20}$) on the pre-test and $K\text{-}R_{20}$ of .64 on the post test. He could not conclude from the study that the astronomy materials of E.S.S.P. increase the student's general understanding of science.

Trent compared the PSSC physics course with a traditional physics course in attaining the objective "understanding science" as measured by TOUS. He used Californian secondary schools with individual schools as the sampling unit and the school mean for TOUS as the statistical unit. He found there was a significant difference and stated that the main implication of the study was

> *that the PSSC and traditional physics courses are equally effective in attaining student science understanding as measured by the T.O.U.S.*
>
> *(Trent, 1965,229)*

Trent did not report a reliability coefficient for the test.

Crumb also compared two physics courses and reported the difference in achievement of students as measured by T.O.U.S. Crumb observed that

> *one objective of science instruction is to develop in students a better understanding of scientists and the nature of their work.*
>
> *(Crumb, 1965,246)*

Crumb also failed to include any reliability measurement for the test.

Kleinman used TOUS scores to test the significance of difference between sexes, ability levels and grades of pupils of high and low teachers. Kleinman concluded cautiously:

> *that the high ability pupils in the seventh and eighth grades who have teachers who ask critical thinking questions have a better understanding of science, of scientists, and of the methods of science than the same caliber pupils of teachers who do not ask critical thinking questions.*
>
> *(Kleinman, 1965,316)*

Schmidt posed the question

> *what is the value of instruments such as TOUS? Do they really measure understanding of science as scientists themselves perceive the scientific enterprise.*
>
> *(Schmidt, 1968,365)*

One hundred and sixteen scientists from the state of Iowa were asked to answer the items on TOUS and the result gave a mean score of 50.8 which is only ten points less than the maximum possible score. In comparison he found that the mean score for teachers of grade seven was 24.9, for teachers of grade nine it was 34.0 and for teachers of grades 11 and 12 it was 41.0.

Klopfer and McCann (1968) used TOUS to compare two courses for freshman students in University High Schools. The two courses were the 'Time Space and Matter' course which had been given for several years and a newly developed Natural Science course. A pre-test method was used and they discovered that students in the natural Science course did significantly better on TOUS than did students in the other course.

They report a reliability coefficient of .65 (K-R_{20}) for the test.

in Australia, Tisher (1967) used TOUS in a study of Queensland science courses and Broadhurst (1968) used it in a study of one hundred and eight senior secondary school chemistry students and their teachers in non-Departmental schools in Sydney.

One of the most comprehensive uses of the instrument in Australia is reported by Mackay (1970). He used TOUS, form W, to measure changes that occur in students' understanding of science as they study integrated science courses in forms 1 to 4 of Victorian secondary schools. A pre-post test design was used in the study.

Mackay determined K-R_{20} reliability coefficients for males and females separately in each of the forms 1 to 4 for both pre and post-tests. The results are summarized in the following table.

TABLE 10: K.R.20 RELIABILITY COEFFICIENTS FOR TOUS FORM W

	Pre-Test	Post-Test
Males 1	.64	.62
2	.82	.70
3	.62	.71
4	.62	.78
Females 1	.60	.62
2	.77	.61
3	.54	.62
4	.59	.62

(Mackay, 1970,63)

Fraser used a version of TOUS in Australia. This modified version was developed by Fraser from a pool of items drawn from the junior and elementary versions of TOUS together with some new items based upon items of the senior version of TOUS. The initial pool was reduced and modified by a panel of experts in Science, educational measurement and science education to improve face validity, suitability for Australian conditions and readability for Grade 7 students. The test was administered to a random third of students in fourteen different grade 7 classes, each class being selected from a different school. The sample size for this particular investigation was 176.

As a result of item analysis and statistical post-trial criteria this instrument was reduced to thirty items suitable for use with grade 7 students in Australian schools. A major achievement by Fraser was the refinement of the three sub scales of the test for three conceptually different aspects of understanding science. Fraser used three criteria that he describes in Research, 1974 as a means of determining the composition of the final instrument. The criteria are:

> A criterion of educational importance is needed to ensure that instruments chosen do measure outcomes that are educationally significant.
>
> A number of subjective pre-trial criteria can be employed both to sieve available instruments to identify those worth subjecting to trial with the target population and to modify instruments prior to trial.
>
> Several statistical post-trial indices can be used to indicate the overall effectiveness of tests and to identify test items in need of modification; these criteria are internal consistency, uniqueness and sensitivity.
>
> (Fraser, 1974,99)

This final version of the Test of Understanding Science, containing the three distinct sub-scales, was given in a pilot run to eight classes of grade 7 students in Tasmanian schools. A random third of the students in these classes was used giving a sample size of 63. The results of this trial were reported by Fisher and Fraser (1974) and the $K\text{-}R_{20}$ reliability coefficients determined were as follows:

TABLE 11: *K-R_{20} RELIABILITY COEFFICIENTS FOR TOUS IN TASMANIAN TRIAL*

SCALE		No. of Items	K.R.20 Reliability
SCALE 1	PHILOSOPHICAL	12	.55
SCALE 2	HISTORIC-SOCIAL	12	.61
SCALE 3	NORMALITY OF SCIENTISTS	6	.60
TOTAL TEST		30	.77

(Fraser and Fisher, 1974,93)

It should be noted that in Australia the names of the three scales were altered from the original three areas proposed by Klopfer and Cooley. However the same important ideas of understanding science as originally identified by Cooley and Klopfer were evaluated. This locally trialled Australian version of TOUS was one of the instruments used in this study. Not only has it been validated quite rigorously but the three scales reflect the aims of ASEP described previously in Chapter II.

Test of Enquiry Skills

The second instrument chosen was one which would measure enquiry skills,since one of ASEP's aims was to develop in children skills that would enable them to carry out scientific investigation. These skills are those rated as important by science writers and are included in Klopfer's classification. The instrument selected was the Test of Enquiry Skills developed by Fraser at Monash University specifically for a summative evaluation of the ASEP curriculum. Klopfer's categories (1971) and the literature survey carried out by Fraser (1974) formed the basis for the development of A Test of Enquiry Skills (TOES). The scope of the skills and the development of the test is described in a paper presented by Fraser to the Australian Science Education Research Association in Queensland, 1973.

> *For the purposes of test construction, it was decided to restrict attention to Klopfer's categories called the process of scientific inquiry. From the literature, ample evidence was collected to support the importance of these goals, which have formed the basis for the development of A Test for Enquiry Skills. The scope of the skills measured in TOES is shown below.*
>
> *A Test of Enquiry Skills*
>
> *PART A - Reference Materials*
>
> *Skill 1 : Library Usage*
> *Skill 2 : Index and Table of Contents*
>
> *PART B - Interpreting and Processing Information*
>
> *Skill 3 : Scales*
> *Skill 4 : Averages, Percentages and Proportions*
> *Skill 5 : Charts and Tables*
> *Skill 6 : Graphs*
>
> *PART C - Critical Thinking in Science*
>
> *Skill 7 : Comprehension of Science Reading*
> *Skill 8 : Design of Experimental Procedures*
> *Skill 9 : Conclusions and Generalisations*

(Fraser, 1973,79)

When writing the trial version of TOES, Fraser used three measures to ensure the validity of items and their suitability at the grade 7 level.

> *"Firstly, extensive use was made of the literature both to clarify the meaning and scope of each skill" and to be sure that each item measured an objective important in science education.*
>
> *Secondly, an extensive review of both published and unpublished evaluation instruments was used as a source of ideas for test items.*
>
> *Thirdly, all items written were subjected to the scrutiny of a panel of experts in educational measurement and in science education.*
>
> *(Fraser, 1973,82)*

This panel which included the author checked the face validity of the items for the skill they were supposed to test. One hundred and seventeen items survived these panel sessions and were administered to fourteen Melbourne grade 7 classes, each at a different school. Random thirds of the class were used on each of Parts A, B and C.

The following $K\text{-}R_{20}$ reliability figures were determined.

TABLE 12: $K\text{-}R_{20}$ RELIABILITY COEFFICIENTS FOR TOES TRIAL

	$K\text{-}R_{20}$
PART A	0.74
SKILL 1: LIBRARY USAGE	0.53
SKILL 2: INDEX AND TABLE OF CONTENTS	0.70
PART B	0.92
SKILL 3: SCALES	0.74
SKILL 4: AVERAGES, PERCENTAGES AND PROPORTIONS	0.83
SKILL 5: CHARTS AND TABLES	0.73
SKILL 6: GRAPHS	0.79
PART C	0.92
SKILL 7: COMPREHENSION OF SCIENCE READING	0.72
SKILL 8: DESIGN OF EXPERIMENTAL PROCEDURES	0.46
SKILL 9: CONCLUSIONS AND GENERALIZATIONS	0.54

(Fraser, 1973,83)

Fraser decided $K\text{-}R_{20}$ values above 0.50 would be accepted and thus all skills had acceptable $K\text{-}R_{20}$ reliability.

Fraser added that

> For all tests in the trial with the exception of Skills 3 and 5, it was found that satisfactory sensitivity had been achieved. That is, except for two skills, each test had a satisfactory spread of item difficulties ranging from very easy to very hard.

(Fraser, 1973,84)

After detailed item analysis the test was revised and the second trial version of TOES was administered to 400 students in 14 grade 7 classes in Melbourne schools.

The following table shows the results of this second version trial.

TABLE 13: RESULTS OF TOES SECOND TRIAL

Subtest	No. of Items	Mean	S.D.	Reliability $K\text{-}R_{20}$	Reliability Test-Retest
Skill 1	10	6.2 (62%)	2.1	0.61	0.74
Skill 2	9	6.7 (74%)	2.4	0.80	0.82
All Part A	19	12.9 (68%)	3.9	0.81	0.87
Skill 3	10[a]	6.1 (61%)	2.6	0.76	0.78
Skill 4	8	3.2 (40%)	2.3	0.77	0.78
Skill 5	11	7.2 (65%)	2.4	0.69	0.65
Skill 6	10	5.7 (57%)	2.8	0.77	0.80
All Part B	39[a]	22.1 (57%)	8.2	0.90	0.83
Skill 7	10	6.7 (67%)	2.0	0.65	0.70
Skill 8	10[b]	5.6 (56%)	2.1	0.60	0.66
Skill 9	9[c]	5.2 (58%)	2.2	0.70	0.67
All Part C	29[d]	17.5 (60%)	5.5	0.84	0.80

(Fraser, 1975)

The test was again revised and then used in a pilot run in Tasmanian schools. This was the same pilot run in which the Test of Understanding Science was used and has been described previously. The pilot run was reported by Fraser and Fisher in 1974. The total TOES test proved to be too long and,as it was to be used with the TOUS test,a shortened version was devised for this study. This version consisted of four scales selected from the scales of the original test which provided a sample of each of the three main areas.

The scales selected were:

TABLE 14: SELECTED SCALES FROM TEST OF ENQUIRY SKILLS

Scale	*No. of Items*
1. Library Usage	*10*
2. Scales	*11*
3. Charts and Tables	*11*
4. Comprehension of Science Reading	*10*

These four scales became the four enquiry skills used in this study.

With the use of the two tests TOUS and TOES seven scales were used in the pre and post test situations. These are listed in the following table, with the K-R_{20} reliability coefficients calculated during the pilot run.

TABLE 15: K.R.20 RELIABILITY COEFFICIENTS FOR TRIAL OF SCALES USED IN THIS STUDY

SCALE	TEST	NAME OF SCALE	K-R_{20} RELIABILITY FROM TRIAL DATA
1	TOUS	Philosophical	0.55
2	TOUS	Historical-Social	0.61
3	TOUS	Normality of Scientists	0.60
4	TOES	Library Usage	0.57
5	TOES	Scales	0.90
6	TOES	Charts and Tables	0.65
7	TOES	Comprehension of Science Reading	0.68

(Fraser and Fisher, 1974,92)

The actual tests used are included in appendices I and II.

CHAPTER V

ANALYSIS OF DATA

The data obtained from the tests were collated and analysed by computer. A number of tests were used to establish whether there were any significant differences between variables, and these are discussed in this chapter.

t-Test

The first set of hypotheses to be tested was 'that there is no difference between pretest score and post-test score for each of the seven criterion variables'. The changes that occur in the mean scores from pretest to post-test for each of the scales are given in table 16 together with the number of items. This table represents the change in mean for the total population. To determine whether this change was significant a t-test for dependent samples was employed. The means, standard deviations, t values and significant figures were all calculated using the computer program Statistical Package for the Social Sciences sub-program T-Test (Nie et al, 1975).

The table indicates that, in all cases, an improvement in mean score was experienced during the year on all of the seven scales. Using t-tests for dependent samples, the differences between pretest and post-test scores was found to be significant at the .001 level of confidence for six of seven scales. The null hypotheses that there is no significant difference between pre test score and post test is therefore rejected for six of the seven tests. The one scale in which there has been no significant change is the philosophical scale.

TABLE 16: t-TEST FOR DEPENDENT SAMPLES FOR PRE TEST-POST TEST CHANGES

VARIABLE	MEANS		STANDARD DEVIATIONS		t
	PRE	POST	PRE	POST	
Philosophical	5.6	5.7	2.2	2.3	1.9
Historic - Social	6.9	7.4	2.4	2.5	9.8 **
Normality of Scientists	3.5	3.8	1.5	1.5	10.7 **
Library Usage	5.0	5.6	2.0	2.0	12.6 **
Scales	5.6	6.4	2.7	2.6	13.9 **
Charts and Tables	5.8	6.2	2.6	2.6	7.3 **
Comprehension	5.0	5.3	2.8	2.8	5.2 **

$^{**}p<.001$

Multiple regression analysis

Because there are significant changes in six of the seven scales a second set of hypotheses involving the differential effectiveness of ASEP materials for pupils of different sex, socio-economic status and school type was tested. In order to test the significance of the differential changes experienced by students of different sex, socio-economic status, school type and curriculum a multiple regression analysis was performed separately for each of the seven scales - criterion variables - using a full regression model containing twenty terms. These were the four variables listed above (two of which SES and school type have three categories giving two more terms, the thirteen two-way interactions possible between the variables, and the pre test.

The total number of students in the sample was 2373 and the distribution of students among the sub groups for the analysis is given in table 17.

TABLE 17: DISTRIBUTION OF STUDENTS THROUGHOUT THE SAMPLE

TOTAL	SEX	SES	SCHOOL TYPE	CURRICULUM
2373	Boys 1177 Girls 1196	High 883 Medium 678 Low 812	High 1859 District 154 Independent 360	ASEP 1728 NON-ASEP 645

Two models of multiple regression were employed in the analysis. Cohen (1975) describes these two types as the hierarchical model and the simultaneous model. In the first part of the multiple regression the heirarchical model is employed. Cohen describes this multiple regression analysis in terms of a formula which can be applied to the present investigation.

$$R_{Y.TUV} = R_{Y.T.} + R_{Y.(T.U.)} + R_{Y.(V.T.U.)}$$

$R_{Y.T.V.U.}$ = *Variance in post test due to pre test*

$R_{Y.T.}$ = *Variance in the post test applicable to the block of main effects over and above that due to the pre test.*

$R_{Y.(V.T.U.)}$ = *Variance in the post test applicable to the block of interactions beyond that applicable to the pre test and the block of main effects.*

(Cohen, 1975,128)

The main effects referred to are the independent variables of sex, SES, school type and curriculum. This hierarchical method is described as Overall and Speigel's Method 2 (Kaufman and Sweet, 1974; Newman and Oravecz, 1977; Overall and Speigel, 1969). Using this method, the amount of variance in post test scores associated with the curriculum variable is estimated, after removal of the variance associated with the pre test and the block of main effects but not the block of two way interactions. When determining the variance due to the other variables for logical reasons the variance due to the pre test was removed first, followed by the variance due to the block of main effects and then the variance due to the two way interactions. Interactions greater than two way are ignored. This order is supported by Cohen (1975) who regards variance due to interactionsas not being as important as the variance due to the main effects.

Individual main effects and individual interactions were interpreted only if the corresponding block was significant. To interpret these individual main effects and interactions Cohen's simultaneous method was used to determine the amount of variance attributable to each. No order was suggested and the unique contribution of each variable was determined. This means that any variance attributed to any main effect was that variance remaining after the variance attributed to the pre tests and all other main effects had been removed. The variance attributed to any interaction was that variance remaining after the variance attributed to the pre test, all main effects and all other interactions had been removed.

Having calculated the variance a decision about whether the amount of variance attributed to any variable is significant or not had to be made. Cohen suggests a formula for the calculation of F values.

$$F_B = \frac{R^2_{Y.AB} - R^2_{Y.A.} \ / \ k_B}{(1-R^2_{Y.ABC})/(n-k-1)}$$

(Cohen, 1975,141)

The determination of the level of significance acceptable is discussed later.

Computer Analysis

In order to use multiple regression the test data was analyzed using the computer program Statistical Package for the Social Sciences (SPSS) sub-program Anova (Kim and Kohout, 1975) because this *sub-program provides a choice of multiple regression methods. For example hierarchical and simultaneous models are provided for and in addition it automatically provides a combined test for whole blocks of variables in addition to tests for individual effects. The sub-program also contains an option of multiple classification analysis which permits ready interpretation of significant main effects and interactions. In addition the designers of the sub-program Anova have taken into account the fact that it is difficult to ensure that all groups in a particular experiment will be of comparable size, i.e. the number of cases falling into the cells are unequal.*

The different designs included in the sub-program are the 'classic' approach which is suitable for the analysis of the data in this study in that each main effect is estimated as a quantity over and above the other main effects, while each interaction is estimated as a quantity over and above all other interactions and all main effects. The 'classic' approach is to partition the total sum of squares (corrected for mean) into the following three types. (The example given is for two variables.)

$SS_{A,B}$ = *sum of squares due to additive effects of A and B*

SS_{AB} = *sum of squares due to interaction effects*

SS_{error} = *sum of squares due to error*

(Kim and Kohout, 1975,405)

The additive effects of A and B are then partitioned into separate main effects. The classic experimental design approach therefore assigns only the portion of $SS_{A,B}$ *that is not accounted for* *by B to A and the portion that is not accounted for by A to B*

$$\text{i.e. } SS_A, \text{ adj for } B = SS_{A,B} - SS_B$$

$$SS_B, \text{ adj for } A = SS_{A,B} - SS_A$$

(Kim and Kohout, 1975,405)

The second approach described in SPSS is called the hierarchical approach. In this approach the main effects are partitioned in a hierarchical manner. For example if A is assigned higher priority than B then the total additive effects are partitioned as

$$SS_{A,B} = SS_A + (SS_{A,B} - SS_B)$$

(Kim and Kohout, 1975,406)

Another advantage of this program is that the order in which variables are entered is controlled by the user. This second approach available in the sub-program was used to distribute the variance for pre test, block of main effects, and interactions in an hierarchical manner. While the variance within the blocks of main effects and interactions is distributed by the 'classic' approach.

The particular SPSS sub-program provides figures for sum of squares, degrees of freedom, mean squares, F values and significance of F values. Values of R^2 *which were required for the regression analysis were obtained by dividing the sum of squares for a particular source by the sum of squares designated as 'total'.*

Significant tests provided by the program do not give any specific information about the pattern of effects, but for the examination of the pattern of effects the sub-program provides an option called multiple classification analysis. The output obtained using this option consists of the grand mean of the dependent variable and a table of 'category means' for each factor expressed as deviations from the grand mean. Hence expressed in this deviation form, the category means reflect the magnitude of the effect of each category of a factor. The category effects are adjusted for all other factors, and the user is able to assess the magnitude of category effects for a given factor that remains after variation due to other factors, pre tests etc. has been removed.

Thus all the statistics required for the analysis of the data are provided in the SPSS sub-program Anova.

Each student in the sample was classified as either high, medium or low socioeconomic status; high, district or independent school type; ASEP or non-ASEP; and according to sex. The seven categories of Congalton's socioeconomic scale were reduced to three, approximately equal groups in order to simplify the analysis of the data. Congaltons groups, 1,2,3, were classified as high; 4,5 as medium; 6,7 as low. These independent variables are therefore categorical and are suitable for use with the selected program.

Selection of level of significance

The .01 level of significance was adopted because of the large sample size and the fact that the individual student was the sampling *unit, and an educationally nonsignificant finding (e.g. that the curriculum variable accounts for 0.1 per cent of the variance) turns out to be statistically significant at the 0.05 level. To support this assertion the formula used for the calculation of the F value can be used to show what increment of variance shows as significant at .05 level, (i.e. what increment in R^2 gives a significant F).*

$$F = \frac{(\Delta R^2)/1}{(1 - .246)/2352}$$

An average F value would be 3.84 for 0.05 sig. level

$$3.84 = \frac{R^2}{.754/2352}$$

$$\Delta R^2 = .0012$$

$$\Delta R^2\% = .12\%$$

Thus it would take only .12% of the variance to give a statistically significant result using the conventional .05. As such a very small increment gives a statistically significant result it appears that the .01 level of significance should be adopted to achieve greater educational significance.

This notion is supported by Labovitz

> *With a large N a small difference is likely to be statistically significant therefore small error rates (.01 or .001) should usually accompany large N's.*
>
> *(Labovitz, 1968,220)*

He comments further that .05 is not sacred and suggests that the selection of a significance level is a complex process. As the N in this study was greater than 2000 it again appears that the .01 level should be selected rather than the .05 level.

An example of how the F value is calculated from R^2 values is shown. This is the formula suggested by Cohen (1975,151) and the data used below is taken from the block of main effects for the philosophical scales.

$$F_b = \frac{(R^2_{Y.AB} - R^2_{Y.A})\ k_B}{(1 - R^2_{Y.ABC})/(n-k-1)}$$

$$= \frac{(.015)/6}{(1 - .192)/(2373-20-1)}$$

$$= \frac{.0025}{(.808)(2352)}$$

$$= 7.28$$

Which is significant beyond .001 level.

$R^2_{Y.AB}$ = Variance due to block of main effects and the one test

$R^2_{Y.A}$ = Variance due to pre-test alone

$R^2_{Y.ABC}$ = Variance due to pre test, block of main effects and two way interactions

k_B = Number of terms in block of main effect

n = Number of sample units

k = Number of terms in full term model

All the F values were calculated by the program in this way.

Summary of analysis procedure

In summary, to analyse the date a multiple regression model of 20 terms was used. The 20 terms of the model consisted of the pre test (1), the block of main effects (6), the two-way interactions (13). Interactions bigger than two-way are excluded from the analysis. Each main effect was estimated as a quantity over and above the other main effects, after the variance attributed to the pretest was removed, while each interaction was estimated as a quantity over and above all main effects and the other interactions. The values of R^2 *(%) required for the interpretation were obtained from the printout by dividing the sum of squares for a particular source by the sum of squares designated as 'total'.*

It should be mentioned that one of the limitations of the analysis was that it does not take into account relationships between the seven criterion variables but treats them separately. However, the data analysis indicated that different patterns emerged from each of the criteria, and by separating them some interesting factors were revealed. Also the original aim was to discover details about each of the seven criteria whether they all correlated or not.
However it is important to realise that the seven criterion variables are regarded as seven different outcomes that are not related to the whole. This notion is supported by Cronbach (1963) who argues that the outcomes of instruction are multi-variate.

Examples of the final printout programs are included in appendix III but a summary of the whole data can be condensed into a table as in table 18. The table shows the percentage of variance in each of the seven post-tests accounted for by pretest, block of main effects, block of two-way interactions and significant individual main effects and interactions. One of the advantages of the chosen method of analysis is that the essential relationships in the data can all be represented in this one table.

TABLE 18. PERCENTAGE OF VARIANCE IN EACH OF SEVEN POST TESTS ACCOUNTED FOR BY PRE TEST, BLOCK OF MAIN EFFECTS, BLOCK OF TWO-WAY INTERACTIONS, AND SIGNIFICANT INDIVIDUAL MAIN EFFECTS AND INTERACTIONS.

SCALE \ R^2(%)	Full 20-Term Model	Pre	Block of Main Effects	Block of Two-way Inter-actions	SIGNIFICANT INDIVIDUAL MAIN EFFECTS				SIGNIFICANT INDIVIDUAL INTERACTIONS
					SEX	SES	School Type	Curric.	
Philosophical	19.2**	16.7**	1.5**	1.0*	0.6** (G>B)		0.3* (I>H,D)		0.4* (Sex x School Type)
Historical-Social	26.4**	24.0**	2.0**	0.5	0.8** (G>B)		0.8** (I,H>D)		
Normality of Scientists	23.7**	21.6**	1.8 **	0.3	1.0** (G>B)		0.3* (I,H>D)		
Library Usage	28.2**	25.0**	2.8**	0.4	0.6** (G>B)	0.7** (H>M,L)	1.1** (I>H>D)		
Scales	27.0**	24.6**	1.7**	0.6			1.0** (I,H>D)		
Charts and Tables	24.9**	21.0**	3.0**	1.0*	1.2** (G>B)		1.3* (I,H>D)		0.5** (Curr. x School Type)
Comprehension	23.0**	19.2**	2.5**	1.2**	0.6** (G>B)		1.5** (H>I>D)	0.4** (C>A)	0.9** (Curr. x School Type)
Mean R^2(%)	24.6	21.7	2.2	0.7					
Degrees of Freedom	20	1	6	13					

*p<.01
**p<0.1

SEX (G = GIRLS B = BOYS)
S. TYPE (I = INDEPENDENT SCHOOLS H = HIGH SCHOOLS D= DISTRICT SCHOOLS)
SES (H = HIGH M = MEDIUM L = LOW)
CURRICULUM (A = ASEP GROUP C = CONTROL GROUP)

The data in table 18 show that the amount of variance due to the block of main effects, over and above that attributable to the pre tests, is significant for all seven of the scales. The variance attributable to the block of two way interactions over and above that due to the block of main effects, and the pre tests is significant for the 'philosophical' scale, the 'charts and tables' scale and the 'comprehension' scale. Where a significant variance is recorded the particular main effect is that attributed to it over and above that attributed to the pre test and other three main effects. For sex there is a significant amount of variance for all measures except 'scales'. For socio-economic status there is only one significant measure on the scale of 'library usage' while for school type the variance is significant for all seven scales. The variance attributed to the difference in curriculum, over and above that attributed to the pre test and all other main effects, is significant for only the 'comprehension' scale. The interpretation of these results is discussed later.

For the two way interactions,the variance attributed over and above that attributed to the pre test, the block of main effects and all other interactions is significant on the 'philosophical' scale, the 'charts and tables' scale and the 'comprehension' scale. For the 'philosophical' scale there is a significant interaction measure for sex X school type. For the 'charts and tables' scale there is a significant interaction for curriculum X school type. There is a further significant interaction for curriculum X school type for the 'comprehension' scale.

In general about twenty five percent of the variance can be accounted for,just about all of which goes into the pre test, a further 2.2 percent is accounted for by the main effects and the remaining 0.7 percent by the two way interactions. Interactions beyond two way are ignored in this analysis.

Having determined that the variance due to a particular main effect was significant over and above that due to the pre test the direction of the differences had to be determined. The original feedback did not provide this information therefore a multiple classification analysis was performed. (The MCA is an option available in SPSS subprogram ANOVA). This required a re-run of the program and the deviations for each of the groups away from the grand mean was calculated.

The output obtained from MCA consists of the grand mean of the dependent variable and a table of category means for each factor expressed as deviations from the grand mean. Expressed in deviation form, the category means reflect the magnitude of the effect of each category of a factor. The adjusted value enables the user to assess the magnitude of category effects for a given factor that remains after variation due to other factors and the pre test has been removed.

TABLE 19 CATEGORY MEANS FOR MALES AND FEMALES: PHILOSOPHICAL SCALE

Sex	Number	Grand Mean	Unadjusted Deviation	Adjusted for other main effects	Adjusted for other main effects and pre test
Male	1177	5.66	- 0.31	- 0.29	- 0.18
Female	1196		+ 0.31	+ 0.28	+ 0.18

For the scores on the post test the females were 0.31 above the grand mean (5.66) while the males were 0.31 below the grand mean. The second column adjusts for the other main effects while the third column adjusts for the other main effects and the pre test. After this final adjustment the girls were 0.18 above the grand mean while the boys were 0.18 below. The direction is clear and girls have performed significantly better than boys on the philosophical scale.

Similar analyses are carried out for the other scales where there was a significant variance attributable to sex differences. The results of the multiple classication analysis for the other criterion variables is shown in table 20.

TABLE 20 CATEGORY MEANS FOR MALES AND FEMALES

Scale	Grand Mean	Sex	Number	Unadjusted Deviation	Adjusted for other main effects	Adjusted for other main effects and pre test
Historical-Social	7.36	Males Females	1177 1196	- 0.39 0.39	- 0.37 0.36	- 0.23 0.23
Normality of Scientists	3.84	Males Females	1177 1196	- 0.29 0.28	- 0.27 0.27	- 0.16 0.16
Library Usage	5.55	Males Females	1177 1196	- 0.32 0.32	- 0.30 0.29	- 0.16 0.15
Charts and Tables	6.17	Males Females	1177 1196	- 0.4 0.4	- 0.38 0.37	- 0.29 0.29
Comprehension	5.30	Males Females	1177 1196	- 0.37 0.36	- 0.33 0.32	- 0.23 0.22

The direction is shown clearly in the table and on all scales where the variance due to sex, over and above that due to the pre test and other main effects is significant, then the girls have performed significantly better than the boys. The only occasion in which there is no difference between the performance of girls and boys on the seven scales tested is repeated for six scales but accepted for the 'use of scales' scale. The socio-economic variable was significant for only one of the seven criterion variables. The socio-economic status of the students appears to have had no influence on the gain from pre to post test for all variables except library usage. To determine the pattern of relationship of socio-economic status to the criterion variable the SPSS sub program ANOVA multiple classification analysis procedure was used again. Initially the low group was omitted from the analysis and it was tested whether a 'dummy variable' (Cohen, 1975) designating high SES or medium SES, accounted for a significant increment in variance in post test beyond that attributable to the pre test and the other three main effects. The results of this analysis are recorded in table 21.

TABLE 21 HIGH AND MEDIUM SES: LIBRARY USAGE SCALE

Scale	Grand Mean	SES	Number	Unadjusted Deviation	Adjusted for other main effects	Adjusted for other main effects and pre test
Library Usage	5.73	High	883	.25	.23	.13
		Medium	678	- .32	- .30	- .16

The analysis was then repeated with the high SES group omitted. The results of this analysis are recorded on table 22.

TABLE 22 MEDIUM AND LOW SES: LIBRARY USAGE SCALE

Scale	Grand Mean	SES	Number	Unadjusted Deviation	Adjusted for other main effects	Adjusted for other main effects and pre test
Library Usage	5.30	Medium	678	.11	.07	.05
		Low	812	- .09	- .06	- .04

The difference between the low SES and medium SES group is only .09 while the difference between the high SES and medium SES groups is .29. It appears that the variance due to SES beyond that due to the pre test and other main effects is that the high SES groups performed significantly better than the medium and low SES groups on the 'library usage' scale. For all other scales tested there was no significant effect of socio-economic status. The null hypothesis that there is no difference between different socioeconomic groups is accepted for six scales but rejected for the scale of 'library usage'.

For the main effect,school type,there was a significant increment in variance in post-test beyond that attributable to the pre test and the other three main effects. The direction of this difference was determined using the same multiple classification analysis technique described previously for the SES variable and performed by the omission of one school type for each run of the program. The results of this analysis are included in table 22 which shows that for the four scales 'historic-social', normality of scientists', scales' and 'charts and tables', the independent and high school types are significantly better than the district school types. For the 'philosophical' scale the independent school type is significantly better than both the high and district school types. For the 'library usage' scale independent school types are significantly better than high school types which are significantly better than district school types. For the 'comprehension' scale the high school types are significantly better than the independent school types which are superior to the district school types. The null hypothesis that there is no significant difference between the performance of the three school types on the seven scales tested is rejected for all scales. With the exception of the 'comprehension' scale students from the independent schools performed either equal to or better than students from the high schools. In every case the performance of students from district schools was inferior to the other two school types.

The fourth main effect was due to the curriculum, which is the impact of the inclusion of ASEP materials into the curriculum compared with their non-inclusion. In only one instance was there a significant increment in variance in post test, beyond that attributed to the other three main effects and the pre test, and this was for the 'comprehension' scale. The direction of this difference was determined by the multiple classification analysis method described previously. The data indicated that the control (non ASEP) group performed better than the ASEP group.

The hypothesis that students with ASEP units included in their curriculum will perform better on the seven content free cognitive outcomes tested has to be rejected for all seven. The only significant difference was in the reverse direction with students who did not use ASEP materials performing better than those who did on the scale measuring 'comprehension'.

Significant Individual Interactions

The variance attributed to particular interactions was that over and above that attributed to the pre test, the block of main effects and all other interactions. The simultaneous model (Cohen, 1975) was used and thus no order was attached to the interactions. On the 'philosophical' scale the one significant interaction was that of sex by school type.

To determine exactly what the interaction was the multiple classification analysis technique was employed again. The program was used with the girls removed from the sample and the analysis shows what the boys scored in different school types when other effects were adjusted for. No absolute meaning is attributed to the score when combined with the grand mean but an order is suggested. The program was used a second time with the boys removed from the sample and the analysis shows what the girls scored in different school types. The results of the output of the two programs is shown in table 23.

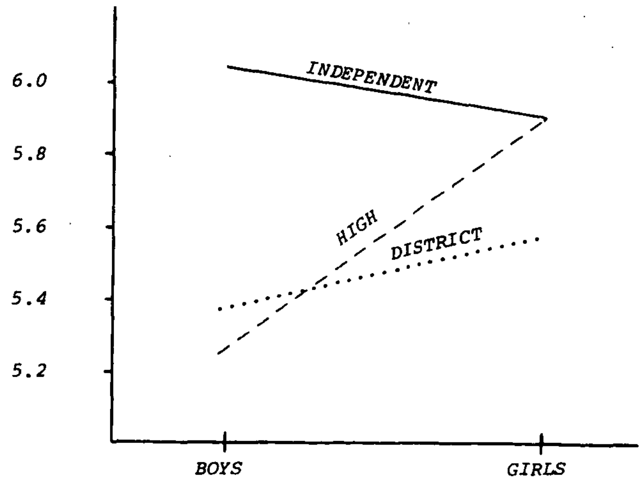
TABLE 23 INTERACTION BETWEEN SEX AND SCHOOL TYPE: PHILOSOPHICAL SCALE

Sex	School Type	Grand Mean	Adjusted * Deviation	Score
Boys	High	5.34	- .10	5.24
	District		.03	5.37
	Independent		.71	6.05
Girls	High	5.96	.03	5.99
	District		- .45	5.51
	Independent		.02	5.98

* (Adjusted for pre test etc. as described previously.)

The results show the interaction more clearly when graphed as in figure 4.

FIGURE 4 SEX X SCHOOL TYPE INTERACTION: PHILOSOPHICAL SCALE



The result confirms the main effect that students of the indpendent school type performed better than the other two. In addition it appears that in independent and district schools sex is virtually unrelated to performance but in high schools girls perform appreciably better than boys. From previous analyses, overall girls perform better than boys but this does not appear to be true for girls of private schools. In high schools it appears that girls perform like independent school students while boys perform like district school students.

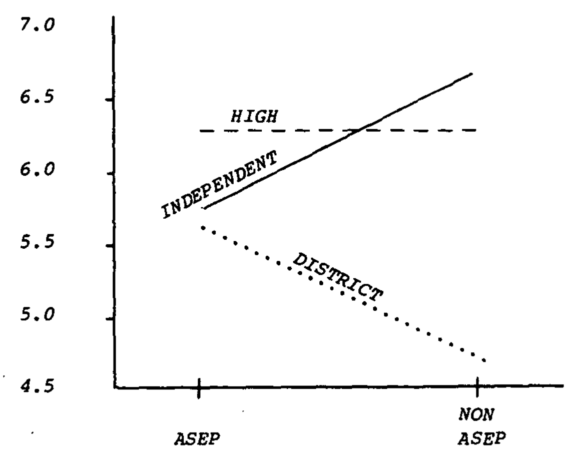
The second significant interaction over and above that attributed to the pre test, main effects and all other interactions occurred in the 'charts' scale. Here the interaction is between the curriculum and the school type. The same multiple classification analysis technique was employed to interpret the interaction. The program was run first with the non ASEP group omitted and then a second time with the ASEP group omitted. The result of the analysis is shown in table 24.

TABLE 24 CURRICULUM X SCHOOL TYPE INTERACTION: CHARTS AND TABLES SCALE

Curriculum	School Type	Grand Mean	Adjusted Deviation	Score
ASEP	High	6.19	.06	6.25
	District		- .56	5.63
	Independent		- .47	5.72
NON ASEP	High	6.12	.15	6.27
	District		- 1.44	4.68
	Independent		.46	6.58

When represented graphically the data appears as shown in figure 5.

FIGURE 5 CURRICULUM X SCHOOL TYPE INTERACTION: CHARTS AND TABLES SCALE



The results show that high school students perform independently of curriculum type on this scale. In the independent schools the non ASEP group out performed the ASEP group while the reverse occurs for the district school students with the ASEP group performing better than the non ASEP group.

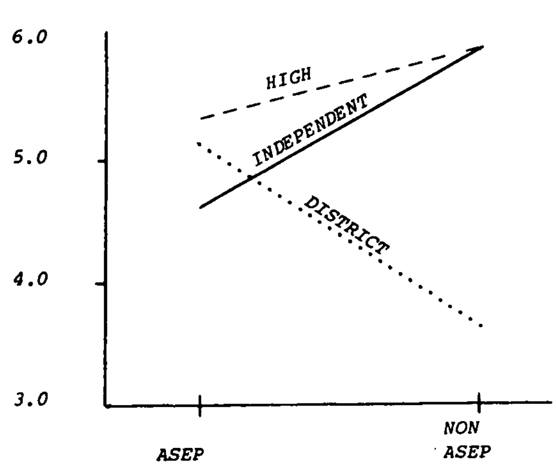
The third significant interaction over and above that attributed to the present, main effects and all other interactions occurs in the 'comprehension' scale. Here the interaction was again between school type and the curriculum used. The type of interaction indicated by the multiple classification analysis is shown on table 25.

TABLE 25 CURRICULUM X SCHOOL TYPE INTERACTION: COMPREHENSION SCALE

Curriculum	School Type	Grand Mean	Adjusted Deviation	Score
ASEP	High	5.22	.07	5.29
	District		- .14	5.08
	Independent		- .65	4.57
NON ASEP	High	5.51	.33	5.84
	District		- 1.87	3.64
	Independent		.38	5.89

When graphed the results appear as in figure 6.

FIGURE 6 CURRICULUM X SCHOOL TYPE INTERACTION: COMPREHENSION SCALE



The students with ASEP materials included in the curriculum are comparable in all schools, however when ASEP materials are not included then the district schools performance is inferior to the other two school types. The district school performance improves with the use of ASEP materials but this is the reverse for the other two school types.

If the two scales 'comprehension' and 'charts' are considered together it appears that district school students benefit if ASEP materials are included in the curriculum.

CHAPTER VI

CONCLUSIONS

The main aim of this study has been to examine the impact of ASEP materials on some cognitive outcomes in grade 7 students in Tasmanian schools. Generally the materials have had virtually no impact on performance on the seven outcomes selected for evaluation. Only one significant curriculum effect emerged from the analysis and that was in favour of the non-ASEP group, which outperformed the ASEP group on the comprehension scale. It may be that students using ASEP materials are not required to read and understand scientific material to the same extent as students using alternative approaches. This assumption is supported by many of the teachers who discussed this result with the author. It would seem that additional scientific readings could be provided for these pupils using ASEP materials.

The most favourable aspect of the use of ASEP materials emerged from the analysis of the interactions, where it appears that the students of district schools benefit from the use of ASEP materials. The pupils of these schools performed better on 'charts and tables' and 'comprehension' with the inclusion of ASEP materials into the curriculum. The provision of ASEP materials to these schools appears to have been beneficial for the student's learning.

The results for the variable, sex, are surprising in that when reporting on Science Education in Nineteen Countries for International Studies in Evaluation, Comber and Keeves (1973) observed that boys outscored girls in all countries in cognitive science tests. The results of the pilot study conducted by Fisher and Fraser in 1974 showed no significant difference in the performance yet in this current study girls have outperformed boys in six of the seven outcomes - no significant difference was observed in the seventh outcome. Gardner (1974) reports that surveys of the literature by Maccoby (1966) and Tyler (1956 and 1969), on differences between the sexes in achievement, have reported that girls usually do better in verbal and linguistic studies than boys, while boys generally do better on tests of numerical, spatial aptitudes, and mathematical reasoning. In rejecting the hypothesis that girls display less scholastic ability than boys Gardner (1974) observes that evidence in fact points the other way: girls tend to achieve better results in school than boys. He writes that -

> Some of the hypotheses which have been advanced to account for this general sex difference include the more rapid maturation of girls, their greater docility and tolerance of uninteresting lessons and more favourable attitudes by teachers towards them.
>
> (Gardner, 1974,234)

However Gardner (1974) reports that the hypothesis, that certain special abilities are required for success in physical sciences and that girls possess less of these abilities than boys, has been researched and there is considerable evidence in support. Other studies by Rowell (1961 and 1971) Pheasant (1961) Grobman (1961,1962) Hughes (1973) Ogunyemi (1973) all indicate that boys significantly outscore girls in science achievement tests.

Nevertheless the data in this survey support the notion that girls are superior to boys in performance on the cognitive outcomes measured. There is no reason to suspect that there are any biases in the sample. It may be that ASEP materials are somehow more suitable for girls,however it should be added there were no significant interaction effects between curriculum and sex. One noteworthy point is that the enquiry skills measured are not practical skills, but rather skills relating to library usage, and handling data. A lot of the data in the literature describe achievement related to practical skills and knowledge of content.

Only one significant difference emerged for socio-economic status, and that was for the library usage outcome where the high socio-economic group performed better than the other two groups. This could be a reflection of the use of general library facilities in the community by the higher socio-economic group, rather than an attribute of the science curriculum. It is generally accepted that the higher socio-economic groups make greater use of these facilities. Generally the ASEP curriculum appears to be equally suitable for all socio-economic groups.

District schools are located in rural areas so that the students of these schools may be designated as country children. Behrens (1977) conducted a study in Tasmania in 1974 and 1975 as a research project commissioned under the education aspect of the Australian Government Poverty Inquiry. Generally he discovered that the country children were a deprived group, noted that they have a lower level of participation in schooling at upper levels, and that their job opportunities are limited. He suggests that in order to reduce the existing inequalities between city and country communities "there is an important need to increase school and work opportunities for country children" (Behrens, 1977,17).

The findings in this study support the results reported by Behrens as on all seven of the outcomes tested the performance of students in district schools was inferior to the performance of the students of the other two school types. One glimmer of hope for the students of these schools is in the interaction between school type and curriculum variables for the scales charts and tables, and comprehension. For these two scales the performance of students in district schools where ASEP materials are provided was better than those who had no access to ASEP materials.

Behrens in the summary of his report writes

> Inherited status or the accidents of place of residence should not affect the opportunities of children to attain a given level of education, to enter the field of work they prefer, or to choose a life style in accordance with their own values.
>
> (Behrens, 1979,19)

Obviously the results of this study would suggest that one area where the children of these schools need increased opportunity is in the area of science education. Useful science materials may be lacking in these schools which could account for the improved performance by students on two outcomes when using ASEP materials. Behrens suggests that the Tasmanian Education Department should discriminate in favour of the district schools and one way this could happen is in the provision of science materials to aid the teachers in these schools.

On two of the outcomes students attending independent schools performed better than students attending high schools. This was on the philosophical and library usage scales. The two aspects measured *by these two scales are apparently treated more favourably in the independent school system, but generally there is little difference between the students of high school and independent schools. On one other variable high school students were superior in performance to independent school students (the comprehension scale), but on the remaining four variables there was no significant difference.*

For the philosophical outcome it was observed that girls in high schools performed much better than boys in the same school type. The boys and girls of independent schools performed better than those of other school types, and the high school girls performed as well as their independent school counterparts. It might be that the inclusion of the more environmentally based ASEP materials has benefited girls more than the boys, although it should be added that no significant interation occurred for curriculum by sex in the analysis. The other significant interactions observed support the notion of the benefit of ASEP materials to the children in district schools. For the charts and tables scale and the comprehension scale this is not so for independent school students and in fact the reverse process occurs. The inclusion of ASEP materials into the curriculum appears to have little effect on students of high schools in their performance on charts and tables, but the inclusion of ASEP materials caused a reduction in their comprehension performance.

The results of this study need to be considered with the results of other studies investigating the effectiveness of ASEP materials. Initially the soundness of ASEP's aims have been supported by the experts' opinions in the literature. The main work in this area has *been reported by Fraser (1974) and the importance of this work is emphasized by Scriven (1967) who argues that if the aims are not important then it is of no consequence if they are achieved.*

A number of studies on the effectiveness of the ASEP materials in achieving long-term outcomes have been carried out. Fraser (1975, 1976) compared ASEP materials with conventional materials on the student achievement of seventeen long term outcomes. Fraser reported that the performance of ASEP students did not differ from that of the control group for sixteen of the seventeen outcomes. The one observable difference was an attitudinal measure of enjoyment of science lessons. Bass (1976) also observed a significant improvement in the enjoyment of science lessons when ASEP materials were used. Fraser and Fisher in what can be considered a pilot study of this study found that significant improvements did occur during the year on 12 out of the 16 outcomes measured when students used ASEP materials. Short term cognitive measures were made by Trebilco (1974) Fraser (1973) Tisher and Power (1973) and generally they concluded that student achievement of the short term aims of single ASEP units improved over time for some, but not all aims considered.

Fraser in a review of research on the Australian Science Education Project observed when discussing the effectiveness of ASEP materials in promoting student achievement of desirable aims for science education that

> *No differences were detected between ASEP and non-ASEP student in achievement of a variety of long-term cognitive aims.*
>
> *(Fraser, 1977,50)*

It would appear that the data gathered in this study support the findings of other studies. One important additional finding established from this study is that ASEP materials were not the only curriculum materials used by science classes. This is consistent with ASEP philosophy which suggest that ASEP materials should be used as part of a curriculum rather than as a whole curriculum. This study is consistent with this philosophy and the impact of the inclusion of ASEP materials into the school's curriculum has been measured. It is interesting to observe that the results are the same as for the tests when one hundred percent ASEP has been used.

Fraser (1977) also observed in his review that several studies consistently showed that ASEP materials generally have a more favourable impact on the attitudes of students to learning science and create a learning environment generally more favourable than do other materials.

A further unique feature of this study is the inclusion of school type as a variable, and the previously discussed data about this variable can now be added to the accumulating knowledge regarding the effectiveness of ASEP materials.

It is apparent that a number of follow-up studies are required on the impact of the inclusion of ASEP materials into the science curriculum of Tasmanian schools. Data should be collected in Tasmania, about the effect of the materials on the attitudes of students to determine whether the included materials cause an increase in the students' enjoyment of science lessons. Further data should be obtained *about the learning environment to determine whether the inclusion of ASEP materials creates classroom learning environment which is different from the classroom learning environment where ASEP materials are not included. A further variable which could be investigated is whether there is any effect on gains on cognitive outcomes when the amount of time devoted to the use of ASEP materials as a percentage of the year's curriculum is included as a variable. It is the intention of the author to investigate these variables in a further study as they are beyond the scope of this present thesis.*

In his model to describe the curriculum Cohen (1964) describes two distinct phases: the developmental phase and the implementation phase. One of the key factors included in the implementation phase is a teacher education program. This is a common feature of many innovation models. Brickell writes that

> *of all the steps in adopting an innovation the most consequential one is training the staff to conduct it.*
>
> *(Brickell, 1971,409)*

It is the author's contention that insufficient funding was provided for the proper innovation of the ASEP materials into the school curriculum through a properly mounted teacher education program. To the classroom teacher an innovation of any type appears to bring with it the apparent problems of extra work load, new approach, confusion and finally a reduced confidence. Therefore there is more security for the teacher in continuing to use the same old materials in the same old way. Hoyle (1971) suggests that a genuine innovation does not occur unless teachers become personally committed to ensuring *its success. Unless the teachers give this committment then the new materials will be used in the same way as the old or as Hoyle suggests they may 'eventually be permanently relegated to store cupboards' (Hoyle, 1971,395).*

The variable general ability was reported in the pilot study by Fisher and Fraser where they recorded that ASEP materials were more effective for pupils of high IQ than those of low IQ on the large number of the cognitive outcomes measured. Unfortunately for reasons given on page 38, this particular variable could not be included in the present study, and a proportion of the variance, not accounted for in the analysis, may be due to this variable. The author's knowledge of the education system in Tasmania would indicate that it was likely that there was a spread of ability throughout the sample of schools.

One other variable not subject to control was the teacher. It is hoped that the variations of teaching style etc. would to some extent be accounted for by the large number of teachers. However caution should be exerted when interpreting the results as the teacher obviously affects the student's learning. Tisher and Power (1973) have measured the achievement of cognitive and affective aims in ASEP classes and noted that this was related to the congruence between the teacher's values about science teaching and those values embodied in ASEP.

The impact of ASEP materials on content-free cognitive outcomes in Tasmanian schools has been minimal and yet the materials have been adopted by many schools. Unfortunately the curriculum innovation has not been as effective as it was hoped and any reasons suggested for this must be regarded as tentative and the opinion of the author.

Although successful in the development of materials, the Australian Science Education Project appears not to have succeeded in the phase of curriculum innovation, as it failed to produce adequate structures which promote changes within the schools. Understandably there were financial reasons for this not to have taken place but it may have been wiser to allocate some of the funds used in the "developmental phase" to the "implementation phase".

Nisbet suggests that there are three significant requirements for successful innovation

> *support services*
> *the involvement of teachers in the process of innovation*
> *and the provision of evaluation*
>
> *(Nisbet, 1971,61)*

Brickell (1971) suggests that the training of teachers in the methods of the innovation may be given either before or during the introduction of the program. The involvement of teachers in the trialling of ASEP materials appears to have had little impact on the effective use of the materials while the minimal teacher education program conducted in Tasmania had little additional effect on the students' learning of the outcomes regarded as important by science educators. It is possible that the ASEP materials were meant to stand alone and provide change through their content but as Stenhouse observes

> *curriculum changes of real significance almost always involve changes of method and ways of working*
>
> *(Stenhouse, 1977,167)*

It would appear likely that the ASEP materials provided new content but the old tried methods of working remained the same as that used with previous materials.

The inclusion of ASEP materials into the school science curriculum of grade 7 classes in Tasmanian schools has had no impact on the students' achievement of content-free cognitive outcomes. Considerable other research has been conducted using ASEP materials and the findings of this study are fairly consistent with this research. The evaluation of the ASEP units at their time of development and their wide acceptance suggests that suitable materials have been developed and it may be at the implementation stage that further financial and educational effort was required. However this is an opinion of the author's and not supported by the results of this study. Further research on ASEP is in progress and many other studies may be instigated in the future. Hopefully this thesis will add to the body of knowledge about ASEP, sex, socioeconomic status and school type and their relation with student achievement of the outcomes regarded by scientists and science educators as being important, and will stimulate further research into this area of curriculum development and evaluation.

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APPENDIX I

TOUS

TEST ON UNDERSTANDING SCIENCE

DIRECTIONS

1. Answer all questions.

2. Do not write on this sheet. All answers should be written on your Response Sheet.

3. To answer each question, choose the best answer and write its letter A, B, C, or D in the space provided on your Response Sheet. Give only one answer to each question.

PRACTICE QUESTION

120. Which one of the following is least likely to be studied by scientists?

A Chemicals

B Boats

C Plants

D Energy

B is the best answer. Therefore, you would write a B next to Question 120 on your Response Sheet, like this:

120. B

4. If you change your mind about a question, just cross out your first answer and write in the new one.

The original form of this test was developed by L.F. Klopfer et al. Copyright by the authors. The present form contains modifications made by B.J. Fraser, Monash University, Victoria.

1. *Scientific discoveries have come from*

   A *almostall countries of the world.*

   B *only countries with big industries.*

   C *only countries with large populations.*

   D *only countries with a hot climate.*

2. *Let's compare scientists with magicians. Which one of the following sentences does this best?*

   A *Scientists and magicians both try to explain things.*

   B *Scientists and magicians both try to make things mysterious.*

   C *Scientists try to explain things, but magicians make them mysterious.*

   D *Magicians try to explain things, but scientists make them mysterious.*

3. *When a scientist finishes a research project, he will usually*

   A *keep his results secret to help his country.*

   B *let other scientists know about his findings and ideas.*

   C *use his results in an invention for industry.*

   D *ask the government for permission to write a report.*

4. *Phil said: 'Machines are taking over so much of our work that they will someday replace the scientists'. Phil's statement is <u>wrong</u> because*

   A *Machines cannot build other machines.*

   B *Machines are not accurate.*

   C *Machines cannot run by themselves.*

   D *Machines cannot think up new ideas.*

5. *When a scientist has a day off, he would probably not like to*

   A *go to his laboratory and work.*

   B *spend some time on his hobby.*

   C *go to a friend's party.*

   D *spend some time with his family.*

6. *Which one of the following groups of people would be hardworking and keen about their jobs?*

   A *Successful people in almost all kinds of work.*

   B *Scientists, but not people in other kinds of work.*

   C *Most people in important work, but not scientists.*

   D *The top scientists, but no other people.*

7. *When several new facts are discovered which do not fit a scientific theory, scientists are likely to*

   A *throw out the theory since the facts do not fit it.*

   B *change the facts a little so that they will fit the theory.*

   C *ignore the facts and keep the theory as it is.*

   D *change the theory a little so that all the facts will fit it.*

8. *Before a scientist announces a new theory to the public, he will most likely talk his ideas over with*

   A *other scientists in his special field.*

   B *newspaper reporters who write about science.*

   C *a group of experts on scientific theories.*

   D *government leaders interested in his theory.*

9. *Which one of the following sentences about modern science is false?*

   A *Modern science is too advanced to use past discoveries.*

   B *Modern science develops modern products.*

   C *Modern science depends on useful inventions.*

   D *Modern science is based on the science of the past.*

10. *Mary likes science. At first, she did not like to write down all the details of her experiments. If Mary becomes a scientist, however, this training could help her to*

    A *be patient in doing her experiments.*

    B *make accurate reports about her experiments.*

    C *think up theories from her experiments.*

    D *work out new experiments to perform.*

11. *How do scientists help mankind?*

    A *They make better things for better living.*

    B *They show us how to be more healthy.*

    C *They give us knowledge about the world.*

    D *They offer skilled service and advice.*

12. *When a scientist completes a new scientific theory, we know that he has*

    A *created one of the laws of nature.*

    B *helped bring mankind closer to the truth of life.*

    C *discovered something new about atoms and molecules.*

    D *developed new understandings about the world.*

13. *A scientist is <u>open-minded</u> about his work if he*

    A *discusses most of his ideas with others.*

    B *considers ideas which go against his own.*

    C *thinks up many new ideas for experiments.*

    D *agrees with the ideas of other scientists.*

14. *Scientists study plants mainly to*

    A *help farmers to produce more food.*

    B *discover how to make new medicine.*

    C *understand how plants live and grow.*

    D *find out where plants will grow best.*

15. *When we say that a scientist has formed a <u>hypothesis</u>, we mean that he*

    A *indicated which measurements were made*

    B *designed equipment needed for an experiment.*

    C *described how an experiment turned out.*

    D *made a careful guess about what will happen.*

16. *Which one of the following is the best list of what scientists study?*

    A *Atoms, molecules, and stars.*

    B *Matter, energy, and living things.*

    C *Plants, animals and disease.*

    D *Rockets, satellites, and space travel.*

17. *Bill always gets good results in school, likes to build model aeroplanes, and plays jokes on his classmates. Frank gets high results in arithmetic, likes to read books, and play baseball. Janet is serious and clēver, and likes to dance. Who could become a scientists?*

    A *Bill only.*

    B *Frank only.*

    C *Janet only.*

    D *Any one of the three.*

18. *The chief purpose of scientists is to*

    A *explain why things happen.*

    B *discover useful inventions.*

    C *make new weapons.*

    D *improve our standard of living.*

19. *The chief purpose of the professional societies which a scientist joins is to*

    A *pay their members good wages.*

    B *sell scientific books to the public.*

    C *keep scientists in touch with one another.*

    D *arrange trips abroad for members.*

20. *Many scientists need bigger and bigger computers and equipment because*

    A *they have more money than they used to have.*

    B *they can then solve more complicated problems.*

    C *the manufacturers don't make small equipment anymore.*

    D *large machines don't become out of date as fast as small ones.*

21. *There are many things happening in the worl which scientists cannot explain. This means that*

    A *there are no scientists doing work on these things.*

    B *all present scientific theories are wrong.*

    C *these things will never be explained.*

    D *there are no theories about these things.*

22. *In chemistry, there have been no new theories in the last forty years. This means that*

    A *scientists know nearly all there is to know about chemistry.*

    B *several new theories will be produced soon.*

    C *most chemists are fairly happy with present theories in chemistry.*

    D *chemists are less clever than they used to be.*

23. *Which one of the following things would an experimental scientist be most likely to do when he is faced with a new problem?*

    A *Read a book on how to solve problems.*

    B *Think up experiments which could help him solve the problem.*

    C *Ask other scientists what the answer is.*

    D *Think about the problem until he arrives at the answer.*

24. *Which one of the following best describes a scientific experiment?*

    A *A series of accurate measurements.*

    B *Careful observations made to test the ideas of scientists.*

    C *Studies made with scientific equipment to prove scientific theories.*

    D *A laboratory procedure as described in a text book.*

25. *Scientists often use mathematics in their theories because*

    A *mathematics is more accurate than normal language.*

    B *scientists are not very good at using normal language.*

    C *scientists like to impress other people by using mathematics.*

    D *scientists are not used to normal language when talking about science.*

26. *Scientists join scientific organizations because*

    A *they are forced to by the government.*

    B *they get to know other scientists.*

    C *they are then able to go overseas.*

    D *they can't keep their work secret otherwise.*

27. *If you were to meet a scientist on the street, he would probably look like*

    A *an eager, hurrying person.*

    B *a quiet, thoughtful person.*

    C *anyone else you might meet.*

    D *an intelligent, young person.*

28. *After a scientist has found the solution to a problem in scientific research, he usually*

    A *seeks a practical application for his discovery.*

    B *feels that the problem is solved once and for all.*

    C *cannot easily find a new problem to work on.*

    D *sees that his work has opened up new problems.*

29. *In trying to decide whether or not to go to a new film, a scientist would be likely to ask himself:*

    A *'Does the film use experimental methods'.*

    B *'Is there something about science in the film'.*

    C *'Will I like this film'.*

    D *'Is the film factual and accurate'.*

30. *Which one of the following statements about <u>models</u> in science is <u>true</u>?*

    A *No more than one model is used to explain the same thing in nature.*

    B *Models are true descriptions of what nature is really like.*

    C *Once a new model is found it should not need changing.*

    D *Scientists use models to help them understand unfamiliar ideas.*

APPENDIX II

TOES

TEST OF ENQUIRY SKILLS

DIRECTIONS

1. *This test is not the usual sort of test. It is simply a way of finding out what things are known by students at school.*

2. *Please try to answer all questions.*

3. *Please do not write on this test. All answers should be written on your Response Sheet.*

4. *To answer each question, choose the one best answer and write its letter, A, B, C, D, or E in the space provided on your Response Sheet.*

PRACTICE QUESTION

120. Which one of the following is usually covered with feathers?

A A fish

B A bird

C A dog

D A snake

B is the best answer. Therefore, you would write a B next to Question 120 on your Response Sheet, like this:

120. B

5. *If you change your mind about a question, just cross out your first answer and write in the new one.*

This test is a shortened version of a test battery developed by B.J. Fraser, Monash University, Victoria. It must not be used without permission.

REFERENCE MATERIALS

Learning about the lives of tribal people can be very interesting. This test is to see how well you can use reference materials to find out information about different tribes.

SKILL 1 : LIBRARY USAGE

In the freezing cold regions of North America there lives a well-known tribe called the Eskimos. To find information about Eskimos, a library is a useful place to look. This test is to see how well you could use a library to find out about Eskimos.

Questions 1-3

Figure 1 below shows copies of several pages from a dictionary. Use these to answer Questions 1-3.

FIGURE 1

HUSKY 530 ICE

ICICLE 531 IDLE

IDOL 532 ILLATION

ILLEGAL 533 IMITATION

IMMATURE 534 IMMUNE

immature, a., not mature.

immediate, a., having no intervening medium; occurring at once.

immemorable, a., not memorable.

immemorial, a., ancient beyond memory.

immense, a., vast, huge; (sl.) very good.

immerse, v., dip or plunge into liquid.

immigrant, n., one who settles in a new country.

imminent, a., impending, about to occur.

immiscible, a., cannot be mixed.

immobile, a., immovable; motionless.

immune, a., secure; exempt.

1. On which dictionary page in Figure 1 would you find the word 'igloo'?

   A Page 530

   B Page 531

   C Page 532

   D Page 533

   E None of the above

2. Only one of the words below has the correct spelling. Figure 1 shows that the word with the correct spelling is

   A immence.

   B emmense.

   C imence.

   D imense.

   E immense.

3. The dictionary pages in Figure 1 show that imminent means

   A famous.

   B not mature.

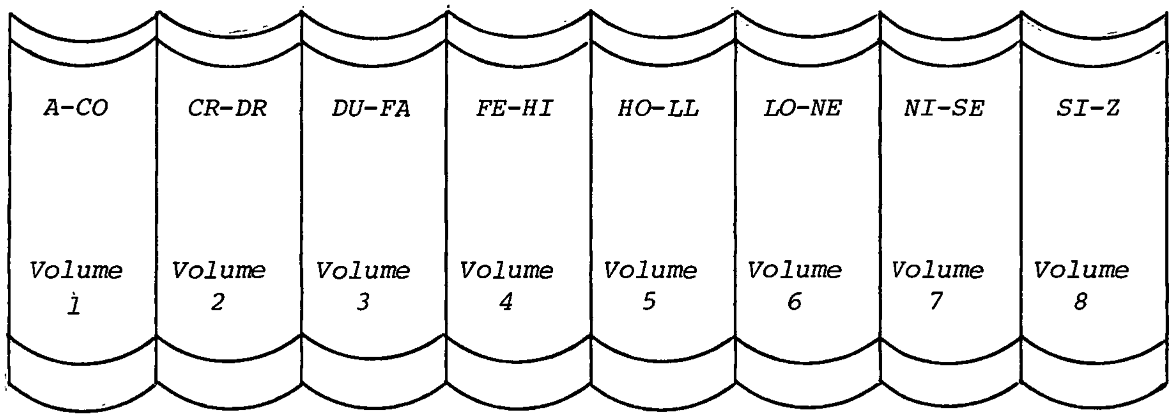
   C about to happen.

   D a person in a new country.

   E very large.

Questions 4-5

Below is a drawing of a set of volumes of an encyclopaedia. Use the drawing to answer Questions 4-5 below.



4. *For food, the Eskimos often catch salmon that have become trapped in the waters beneath the ice. In which volume of the encyclopaedia would you first look to find as much information as possible about salmon?*

   A Volume 1

   B Volume 3

   C Volume 5

   D Volume 7

   E Volume 8

5. *In which one of the following volumes would you first look for a picture of all of these: a salmon, a whiting and a sardine?*

   A Volume 3

   B Volume 4

   C Volume 5

   D Volume 7

   E Volume 8

Questions 6-8

Below is a list of five references found at the back of a book on Eskimos. Use these references to answer Questions 6-8 below.

References

Reference 1	*Bandi, Mary, Eskimo History, London: Meuthen, 1969.*
Reference 2	*Carpenter, Ann S., 'Eskimos', The Tribal Studies Journal, Vol.15, May 1970, pp.37-45.*
Reference 3	*Henry, Norman, The Eskimo of North Alaska, Washington:*
Reference 4	*Honigmann, John M., Eskimo Townsmen, New York: Prentice-Hall, 1965.*
Reference 5	*Wright, James W., Eskimos of the Nushagak River, Melbourne: Macmillan, 1967.*

6. *In which of the above references would you first look to find information about Eskimos in the eighteenth century?*

   A *Reference 1*

   B *Reference 2*

   C *Reference 3*

   D *Reference 4*

   E *Reference 5*

7. *Name the author of The Eskimo of North Alaska*

   A *Norman Henry*

   B *Henry Norman*

   C *Washington*

   D *Wiley John*

   E *John Wiley*

8. *In which part of the book Eskimo History would you look for an alphabetical (A, B, C) list of the topics contained in that book?*

   A *The introduction*

   B *The preface*

   C *The table of contents*

   D *The appendix*

   E *The index*

Question 9

One of the references previously given was:

Reference 5 Wright, James W., Eskimos of the Nushagak River, Melbourne: Macmillan, 1967.

In order to find this book in a library, you could use a library card index. The diagram below shows the letters that appear on the front of each of the drawers of a library card index.

AUTHOR & TITLE INDEX		
Aa-Be	Gu-Ku	Pr-Re
Bi-Ep	La-Mu	Ri-Um
Eq-Gr	Na-Po	Un-Zy

SUBJECT INDEX	
A-D	M-P
E-G	Q-S
H-L	T-Z

LIBRARY CARD INDEX

9. *The easiest way to find Reference 5 in the library card index above would be to look in the drawer marked*

A Gu-Ku

B E-G

C La-Mu

D T-Z

E Un-Zy

Question 10

The library index card for Reference 5 is shown below.

WRIGHT, James W.   971.46
W969E

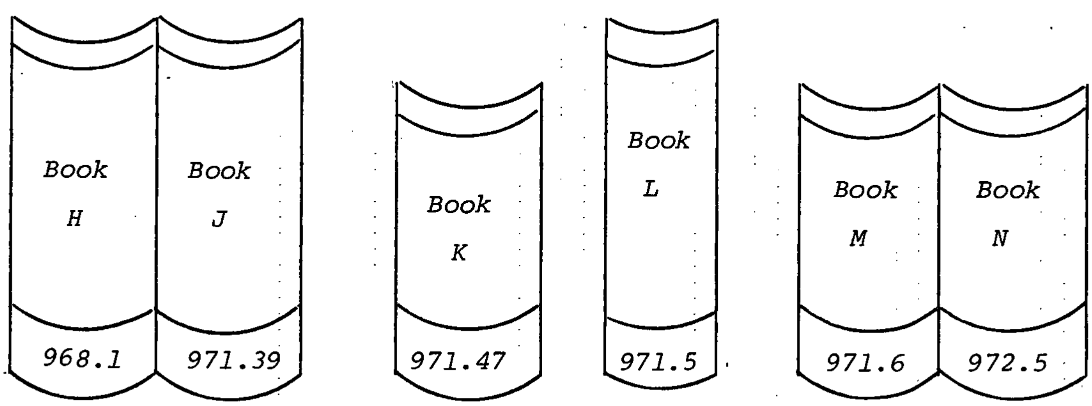
Eskimos of the Nushagak River

Melbourne, Macmillan, (1967)

1. Eskimos - United States - Alaska
2. Nushagak River - Alaska
3. Arctic America - Eskimo

LIBRARY INDEX CARD

The part of the library shelf that would contain the above book is shown in Figure 2.



10. The book called Eskimos of the Nushagak River belongs on the library shelf of Figure 2

A Between Book H and Book J.

B Between Book J and Book K.

C Between Book K and Book L.

D Between Book L and Book M.

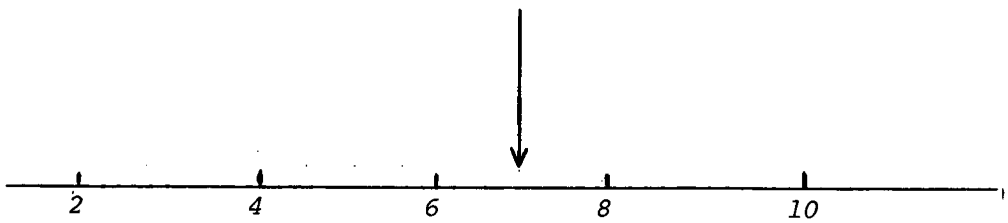
E Between Book M and Book N.

INTERPRETING AND PROCESSING INFORMATION

SKILL II : SCALES

Questions 11-14

11. *The diagram below shows some of the mile posts along a country road.*



Warren runs out of petrol at the point marked by the arrow in the above diagram. If there was a mile post at this point, what reading would it show?

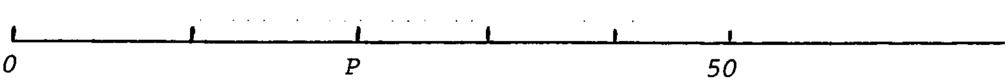
A 6

B $6\frac{1}{2}$

C 7

D $7\frac{1}{2}$

E 8

12. 

What is the reading at Point P?

A 30

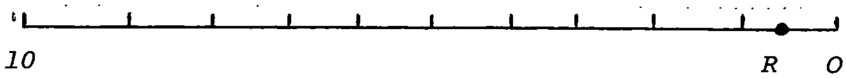
B 25

C 2

D 10

E 20

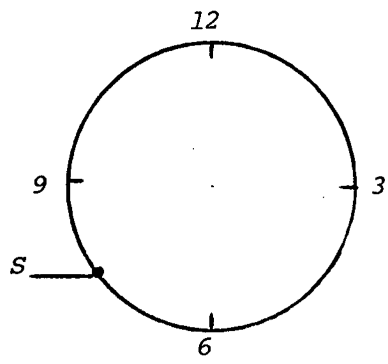
13.



What is the reading at Point R?

A	½
B	1
C	8½
D	9
E	9½

14.

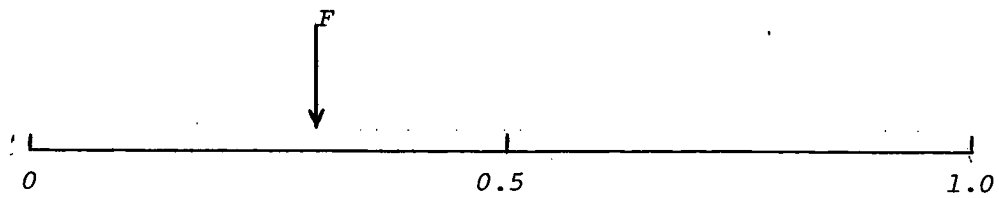


What is the reading at Point S?

A	2.5
B	6.0
C	6.5
D	7.0
E	7.5

<u>Questions 15-18</u>

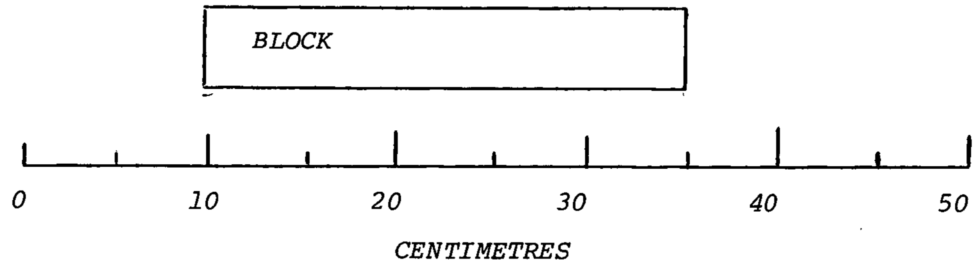
15. *In a frog jumping competition a frog landed at the point marked by the arrow F in the diagram below.*



What is the reading at F?

A	1.25
B	0.30
C	0.40
D	0.45
E	0.70

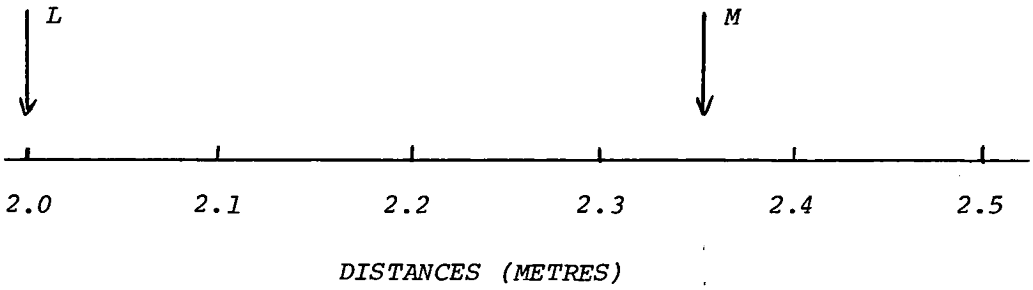
16.



The length of the block of wood in the above diagram is

A	25 centimetres
B	20 centimetres
C	15 centimetres
D	30 centimetres
E	35 centimetres

17. *A beetle started crawling at L and crawled to M in the fiture below.*



How far did the beetle crawl?

A 2.40 metres

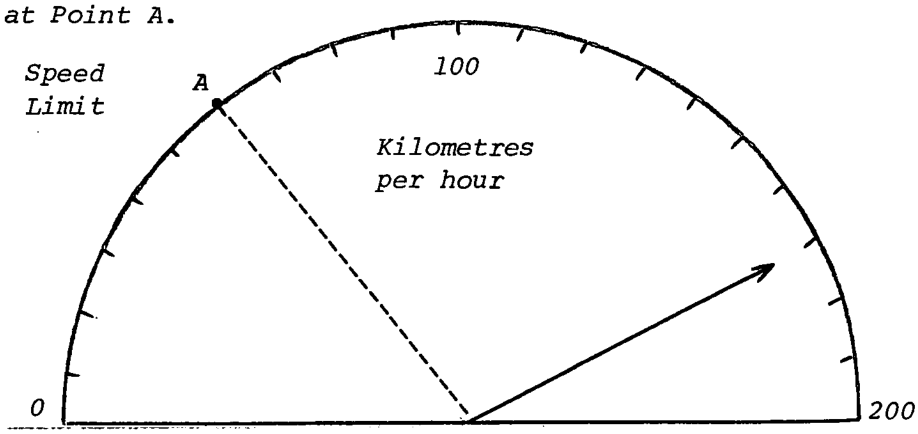
B 2.35 metres

C 0.40 metres

D 0.35 metres

E 0.30 metres

18. *The diagram below shows a car speedometer. The speed limit is shown at Point A.*



When the speedometer pointer is in the position shown, the car is exceeding the speed limit by

A 60 kilometres per hour.

B 110 kilometres per hour.

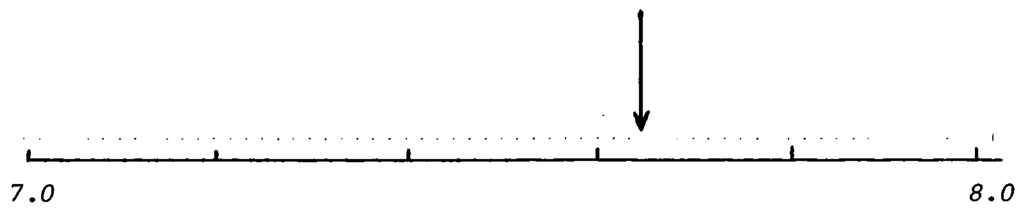
C 140 kilometres per hour.

D 165 kilometres per hour.

E 170 kilometres per hour.

Questions 19-21

19. FIGURE 3



To what reading is the arrow pointing in Figure 3?

A 7.32

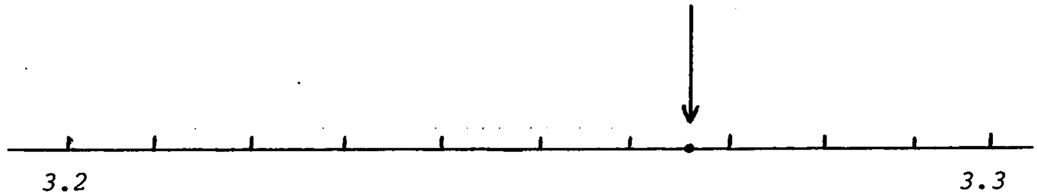
B 7.34

C 7.62

D 7.64

E 8.28

20. FIGURE 4



To what reading is the arrow pointing in Figure 4?

A 3.234

B 3.260

C 3.266

D 3.274

E 3.860

21. *Mrs. Hughes wanted to find out the weight of some steak. Figure 5A shows her kitchen scales without the steak on the scales. Figure 5B shows the scales with the steak on them.*

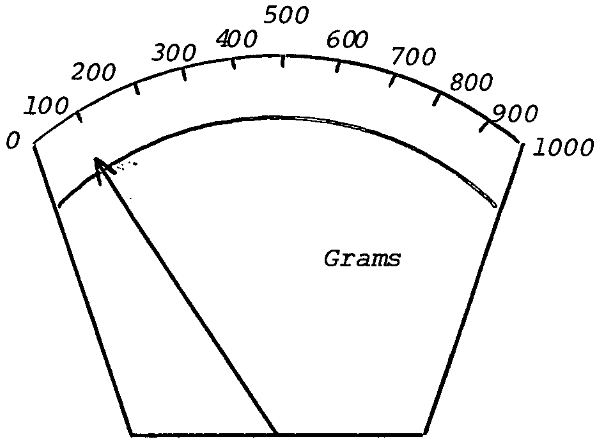


FIGURE 5A

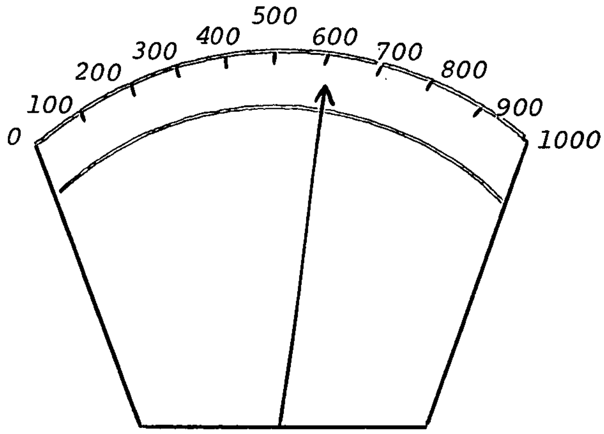


FIGURE 5B

How much does Mrs. Hughes' steak weigh?

A	*100 grams*
B	*500 grams*
C	*600 grams*
D	*700 grams*

SKILLS III : CHARTS AND TABLES

Questions 22-24

At Bunyip High School there are 36 students in Form 6A. These students either walk to school or travel by train, car, bus or cycle. Figure 6 shows the number of students using each of these methods of travel. Use Figure 6 to answer Questions 22-24 below.

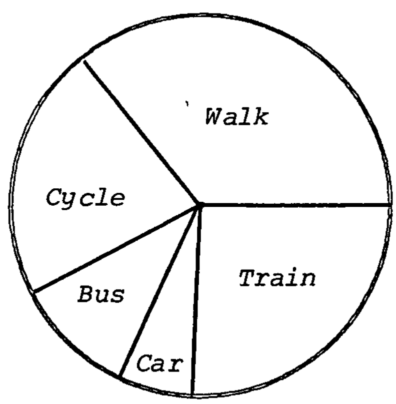


FIGURE 6.

22. *The two methods of travel which are used by about the same number of students are*

    A *Train and Walk.*
    B *Bus and Train.*
    C *Cycle and Train.*
    D *Walk and Cycle.*
    E *Bus and Car.*

23. *The number of students who walk to school is equal to the combined number who use*

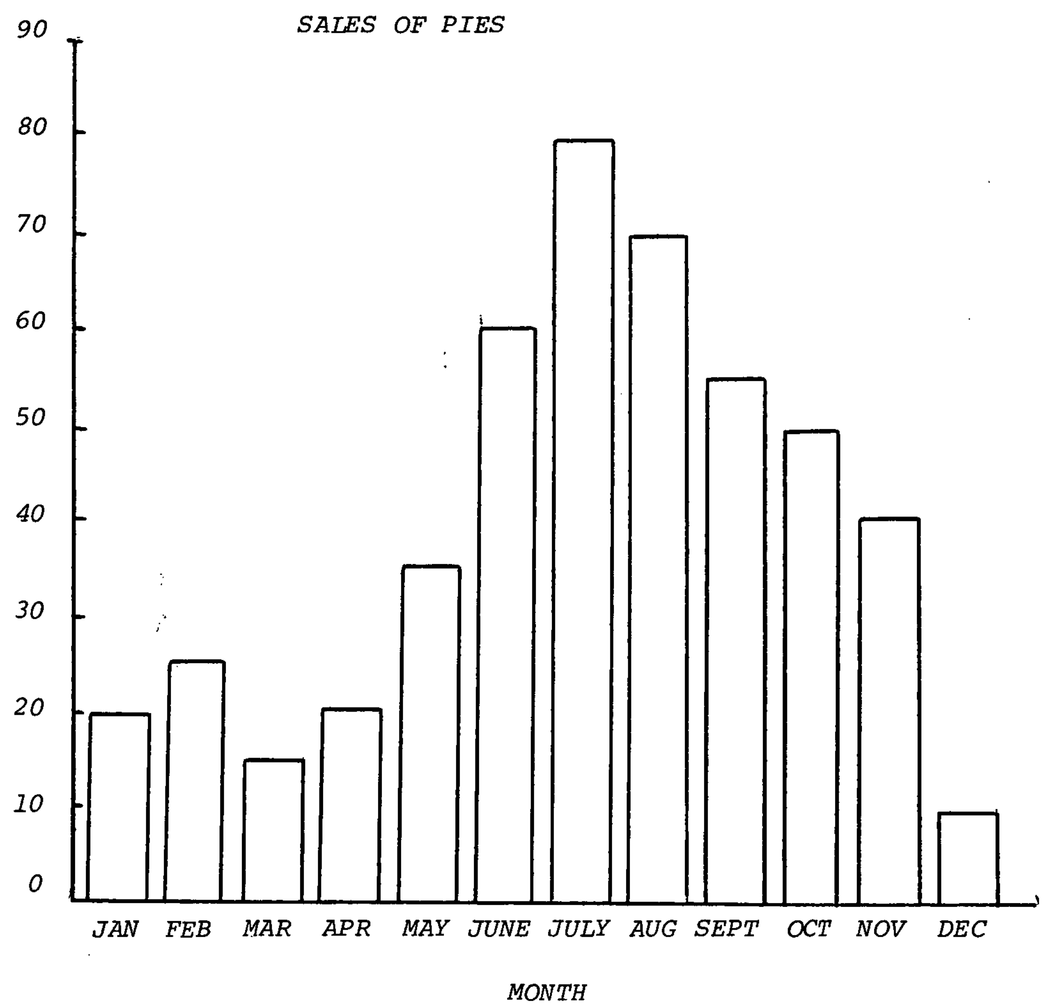
    A *Car and Cycle.*
    B *Cycle and Train.*
    C *Train and Bus.*
    D *Bus and Car.*
    E *Train, Car and Bus.*

24. *We can tell from Figure 6 that*

    A *no student in Form 6A uses trams to come to school.*
    B *some students cycle some days but walk other days.*
    C *the students coming by car have their own licences.*
    D *the students who come by train also come by bus.*
    E *there are few buses that pass the school.*

Question 25

The diagram below shows the number of pies sold in a local city during different months of last year.



25. *The pie sales for February and August combined are equal to the combined sales in*

    A October and November.

    B July and December.

    C June and November.

    D September and May.

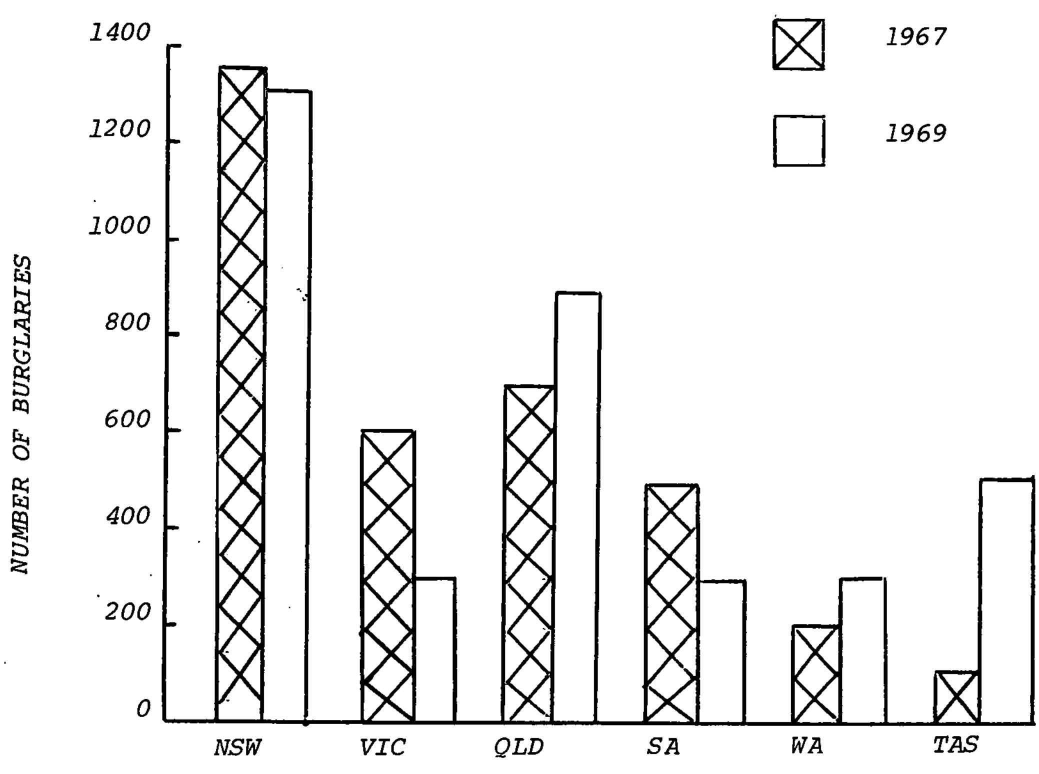
    E May and June.

Questions 26-30

The figure below shows the number of burglaries in various Australian States during 1967 and 1969. Use this figure to answer Questions 26-30 below.

CRIME IN AUSTRALIA

Statistics for house Burglaries for Years 1967 and 1969



26. Which state had 500 burglaries in 1967?

A Tasmania

B South Australia

C Victoria

D Western Australia

E Queensland

27. *The difference between the number of burglaries in Tasmania in 1967 and 1969 was*

    A 400

    B 450

    C 500

    D 550

    E 600

28. *Which state had the smallest change in the number of burglaries over the two year periods?*

    A Queensland

    B Western Australia

    C South Australia

    D Victoria

    E New South Wales

29. *In which one of the following pairs of States did each State have more burglaries in 1967 than in 1969?*

    A New South Wales and Queensland

    B South Australia and Western Australia

    C Queensland and Victoria

    D New South Wales and Victoria

    E South Australia and Tasmania

30. *The number of burglaries in Queensland in 1967 was greater than the number in Victoria in 1969 by*

    A 100

    B 200

    C 300

    D 400

    E 600

Questions 31-32

The figure below shows the rainfall for six Australian cities during a period of seven months. Use this figure to answer questions 31-32 below.

RAINFALL (CENTIMETRES)

CITY	MONTH							
	Jan	Feb	Mar	April	May	June	July	Total
Bourke	3.5	4.0	3.0	2.8	2.5	3.0	2.3	21.1
Darwin	40.5	31.0	28.0	7.8	0.8	0.3	0.0	108.4
Perth	0.8	1.3	2.3	4.5	12.8	19.0	17.8	58.5
Sydney	9.8	8.0	11.0	14.3	12.5	9.3	12.3	77.2
Alice Springs	4.3	3.3	2.8	1.0	1.5	1.3	0.8	15.0
Hobart	4.5	4.8	5.3	5.8	4.3	5.8	5.8	36.3

31. *Which city has the same rainfall in three different months?*

    A Alice Springs

    B Hobart

    C Sydney

    D Bourke

    E Perth

32. *During the whole seven months period, which city had the second highest total rainfall?*

    A Hobart

    B Perth

    C Darwin

    D Bourke

    E Sydney

CRITICAL THINKING IN SCIENCE

SKILL : IV COMPREHENSION OF SCIENCE READING

This is a test to see how well you can understand what you read. Below you will be given information to read and then questions to answer. To answer the questions below, you should use only the information given.

Question 35

Banana growers want to earn as much money as possible. To do this they have to sell more fruit.

There are problems involved in the transport of bananas from Queensland to Melbourne.

Sometimes the fruit becomes dried out during its journey south. Partly lining the boxes with wax paper prevents this happening.

During the train trip they are shaken continuously and may become too soft and ripe to eat when they arrive in Melbourne. To prevent this happening they are picked from the tree when they are hard and green.

However fruit shops in Melbourne cannot sell hard green bananas. To overcome this problem the bananas are stored in rooms filled with nitrous oxide (laughing gas). This is done for a day before they go to the shops. It ripens them. Therefore the customers can buy light, yellow, firm, juicy fruit.

33. Banana boxes are partly lined with wax paper to

A help ripen the bananas quickly.

B keep the nitrous oxide gas inside the box.

C prevent fruit flies getting into the box.

D keep the moisture in the fruit.

Questions 34-36

Use the following paragraphs to answer Questions

Par.1 *Christian Eijkman, a Dutch Army Doctor, was a member of a medical team sent to study the disease Beri Beri in the people of Dutch East Indies. During the 1890's this dreaded disease killed millions of people every year.*

Par.2 *When Eijkman was visiting a native prison on the island of Java, he noticed that the chickens in the prison yard were showing signs of the disease.*

Par.3 *Like the prisoners, the chickens held their heads at an unnatural angle and walked in a strange manner. Yet chickens outside the prison were healthy.*

Par.4 *Chickens outside the prison ate a variety of foods while the chickens inside ate only polished rice left over from the prisoners' meals.*

Par.5 *Eijkman suggested the disease might be a matter of diet.*

Par.6 *Starting with healthy chickens, Eijkman divided them into two groups. Group 1 was fed whole rice grain, and Group 2 was fed polished rice, that is, rice without the brown skin.*

Par.7 *Chickens in Group 1 remained health, while those in Group 2 developed the disease.*

Par.8 *Eijkman decided that the brown skin of the rice contained something which prevented the disease Beri Beri. (It was Vitamin B).*

34. Christian Eijkman was sent to the Dutch East Indies especially to

A study the prisoners.

B grow rice for the prisoners.

C find a method of polishing rice.

D cure diseases in chickens.

E study the disease Beri Beri.

35. The disease Beri Beri is found in

A chickens and humans.

B humans only.

C chickens only.

D rice only.

E rice and chickens.

36. The paragraph which describes part of a theory to explain observation is

A Paragraph 1.

B Paragraph 2.

C Paragraph 3.

D Paragraph 5.

E Paragraph 6.

Questions 37-39

Use the following paragraphs to answer Questions

Par.1 *Did you know that many bird songs are not for the enjoyment of man but a means of telling other birds to stay away? Before selecting a female for a mate the male bird stakes out a territory. He does this by fighting with, and chasing out, other birds from a chosen area.*

Par.2 *After a mate is selected a nest is built by the pair of birds and eggs are laid by the female. Usually it is the mother bird that keeps the eggs warm. She sits on the nest for many days while the eggs are incubating.*

Par.3 *During the first few weeks after the young birds hatch they eat a huge amount of food. The poor parent birds are kept so busy flying long distances to collect suitable food that they get very thin.*

Par.4 *The young bird which hatches first gets most of the food, grows faster and may even push other young birds out of the nest.*

Par.5 *While on the ground the fledglings are quickly eaten by enemies such as owls and cats.*

Par.6 *Some parent birds overcome the food problem by collecting and storing food for a few days before the eggs are due to hatch.*

Par.7 *One such bird is the crested bellbird. These birds collect caterpillars, cripple them and place them on the branches of a tree near the nest.*

37. *Parent birds can become very thin ifthey*

    A *spend a lot of time singing.*

    B *search for food most of the time.*

    C *get pushed out of the nest.*

    D *eat crippled caterpillars.*

    E *sleep on the ground.*

38. *The way a bird claims its living area is described in*

    A *Paragraph 1.*

    B *Paragraph 2.*

    C *Paragraph 4.*

    D *Paragraph 5.*

    E *Paragraph 6.*

39. *Parent bellbirds place a lot of crippled caterpillars on branches near the nest to*

    A *decorate the trees.*

    B *attract other caterpillars to the tree.*

    C *frighten away other birds.*

    D *have a large amount of food in reserve.*

    E *supply the food for fledglings that have fallen out of the nest.*

Question 40

Ninety-two different chemical elements can be found in the earth. The following table provides information about some of these elements.

NAME OF ELEMENT	*APPEARANCE WHEN PURE*	*A COMMON WAY THE ELEMENT OCCURS*
Aluminium	*light grey shiny metal*	*combined with oxygen in clay*
Carbon	*shiny black solid*	*by itself as coal*
Oxygen	*colourless gas*	*by itself in air or combined with hydrogen in water*
Chloride	*greenish yellow gas*	*combined with sodium in table salt*
Platinum	*heavy white metal*	*by itself*
Silicon	*brown powder*	*combined with oxygen in clay*
Iodine	*bluish grey solid*	*by itself as particles in sea water*
Nitrogen	*colourless*	*by itself in air*

40. The element silicon could be obtained from

A *the air.*

B *a packet of kitchen salt.*

C *clay in the garden.*

D *rainwater.*

E *seawater.*

Question 41

Friction is a force that can act between two objects when one is moving across the surface of the other.

In an experiment, several flat blocks made of the same metal were allowed to slide down a wooden plank. For this experiment, the amount of friction increases with the weight of the moving block but not with the area of contact between the block and the plank.

The following table shows the weight of these blocks together with the area of the surface of each block touching the plank. Use this table to answer Question 41 below.

BLOCK	WEIGHT OF BLOCK (Newtons)	AREA OF CONTACT (Square Centimetres)
A	5	300
B	3	400
C	1	350
D	4	500
E	2	450

41. The greatest amount of friction will occur between the plank and

A Block A.

B Block B.

C Block C.

D Block D.

E Block E.

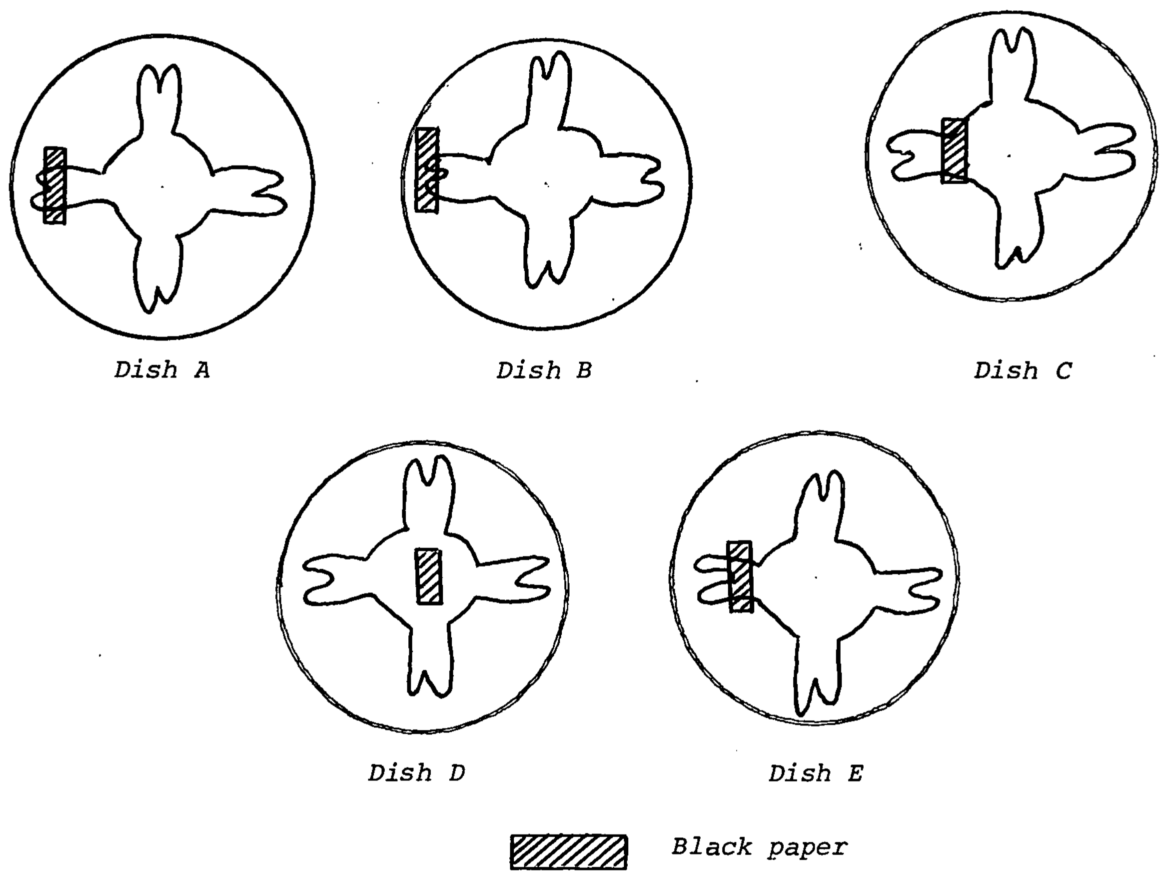
Question 42

There is a small jellyfish which crawls around the bottom of ponds. It has a central body with four radiating branched arms.

There are four light receptors, one at the junction where each arm joins the body.

One branch of each arm ends in a suction pad and the other branch ends in a disc covered with stinging cells.

During an experiment, a jellyfish was placed in each of the 5 dishes shown below. Part of each of these jelly fish were covered with black paper as shown.



42. *A light receptor of the jellyfish is covered with black paper in*

A Dish A.

B Dish B.

C Dish C.

D Dish D.

E Dish E.

APPENDIX III

ANALYSIS OF VARIANCE

APHIL
BY SEX
SES
STYPE
CURR
WITH BPHIL

SOURCE OF VARIATION		SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES		2121.436	1	2121.436	484.745	.001
BPHIL		2121.436	1	2121.436	484.745	.001
MAIN EFFECTS		191.767	6	31.961	7.303	.001
SEX		73.008	1	73.008	16.682	.001
SES		39.436	2	19.718	4.506	.011
STYPE		44.249	2	22.124	5.055	.007
CURR		2.066	1	2.066	.472	.999
2-WAY INTERACTIONS		125.464	13	9.651	2.205	.008
SEX	SES	3.956	2	1.978	.452	.999
SEX	STYPE	53.292	2	26.646	6.089	.003
SEX	CURR	10.444	1	10.444	2.386	.118
SES	STYPE	28.421	4	7.105	1.624	.164
SES	CURR	27.739	2	13.869	3.169	.041
STYPE	CURR	17.520	2	8.760	2.002	.133
EXPLAINED		2438.667	20	121.933	27.862	.001
RESIDUAL		10293.273	2352	4.376		
TOTAL		12731.941	2372	5.368		

ANORM
BY SEX
SES
STYPE
CURR
WITH BNORM

SOURCE OF VARIATION		SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES		1209.175	1	1209.175	666.110	.001
BNORM		1209.175	1	1209.175	666.110	.001
MAIN EFFECTS		99.619	6	16.603	9.146	.001
SEX		56.828	1	56.828	31.305	.001
SES		10.124	2	5.062	2.789	.060
STYPE		17.775	2	8.888	4.896	.008
CURR		5.827	1	5.827	3.210	.070
2-WAY INTERACTIONS		19.460	13	1.497	.825	.999
SEX	SES	7.407	2	3.703	2.040	.128
SEX	STYPE	2.113	2	1.057	.582	.999
SEX	CURR	.311	1	.311	.172	.999
SES	STYPE	5.918	4	1.480	.815	.999
SES	CURR	6.049	2	3.024	1.666	.187
STYPE	CURR	.740	2	.370	.204	.999
EXPLAINED		1328.253	20	66.413	36.585	.001
RESIDUAL		4269.536	2352	1.815		
TOTAL		5597.790	2372	2.360		

AHIST
BY SEX
SES
STYPE
CURR
WITH BHIST

SOURCE OF VARIATION		SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES		3680.215	1	3680.215	766.337	.001
BHIST		3680.215	1	3680.215	766.337	.001
MAIN EFFECTS		307.900	6	51.317	10.686	.001
SEX		119.419	1	119.419	24.867	.001
SES		39.059	2	19.530	4.067	.017
STYPE		117.850	2	58.925	12.270	.001
CURR		21.456	1	21.456	4.468	.033
2-WAY INTERACTIONS		72.644	13	5.588	1.164	.300
SEX	SES	10.869	2	5.434	1.132	.323
SEX	STYPE	17.590	2	8.795	1.831	.158
SEX	CURR	6.335	1	6.335	1.319	.249
SES	STYPE	5.971	4	1.493	.311	.999
SES	CURR	16.816	2	8.408	1.751	.172
STYPE	CURR	13.200	2	6.600	1.374	.252
EXPLAINED		4060.759	20	203.038	42.279	.001
RESIDUAL		11295.110	2352	4.802		
TOTAL		15355.869	2372	6.474		

ALIB
BY SEX
SES
STYPE
CURR
WITH BLIB

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES	2488.010	1	2488.010	820.746	.001
BLIB	2488.010	1	2488.010	820.746	.001
MAIN EFFECTS	280.621	6	46.770	15.429	.001
SEX	55.431	1	55.431	18.286	.001
SES	68.134	2	34.067	11.238	.001
STYPE	112.924	2	56.462	18.626	.001
CURR	3.819	1	3.819	1.260	.261
2-WAY INTERACTIONS	38.377	13	2.952	.974	.999
SEX SES	1.797	2	.899	.296	.999
SEX STYPE	4.549	2	2.274	.750	.999
SEX CURR	2.103	1	2.103	.694	.999
SES STYPE	17.000	4	4.250	1.402	.230
SES CURR	13.114	2	6.557	2.163	.113
STYPE CURR	3.889	2	1.944	.641	.999
EXPLAINED	2807.008	20	140.350	46.299	.001
RESIDUAL	7129.853	2352	3.013		
TOTAL	9936.861	2372	4.189		

ASCAL
BY SEX
SES
STYPE
CURR
WITH BSCAL

SOURCE OF VARIATION		SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES		4043.439	1	4043.439	792.324	.001
BSCAL		4043.439	1	4043.439	792.324	.001
MAIN EFFECTS		287.144	6	47.857	9.378	.001
SEX		5.895	1	5.895	1.155	.282
SES		43.338	2	21.669	4.246	.014
STYPE		168.189	2	84.095	16.479	.001
CURR		19.906	1	19.906	3.901	.046
2-WAY INTERACTIONS		101.090	13	7.776	1.524	.101
SEX	SES	4.428	2	2.214	.434	.999
SEX	STYPE	1.458	2	.729	.143	.999
SEX	CURR	22.309	1	22.309	4.371	.035
SES	TYPE	26.772	4	6.693	1.311	.262
SES	CURR	29.783	2	14.892	2.918	.053
STYPE	CURR	15.073	2	7.537	1.477	.227
EXPLAINED		4431.673	20	221.584	43.420	.001
RESIDUAL		12002.883	2352	5.103		
TOTAL		16434.555	2372	6.929		

ACHTS
BY SEX
SES
STYPE
CURR
WITH BCHTS

SOURCE OF VARIATION		SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES		3368.931	1	3368.931	657.016	.001
BCHTS		3368.931	1	3368.931	657.016	.001
MAIN EFFECTS		476.769	6	79.461	15.497	.001
SEX		193.255	1	193.255	37.689	.001
SES		36.830	2	18.415	3.591	.027
STYPE		215.741	2	107.871	21.037	.001
CURR		.053	1	.053	.010	.999
2-WAY INTERACTIONS		158.586	13	12.199	2.379	.004
SEX	SES	16.290	2	8.145	1.588	.202
SEX	STYPE	.425	2	.213	.041	.999
SEX	CURR	.503	1	.503	.098	.999
SES	STYPE	36.466	4	9.116	1.778	.129
SES	CURR	35.091	2	17.546	3.422	.032
STYPE	CURR	73.871	2	36.935	7.203	.001
EXPLAINED		4004.286	20	200.214	39.046	.001
RESIDUAL		12060.174	2352	5.128		
TOTAL		16064.459	2372	6.773		

```
        ACOMP
     BY SEX
        SES
        STYPE
        CURR
   WITH BCOMP
```

SOURCE OF VARIATION		SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES		3611.785	1	3611.785	586.322	.001
BCOMP		3611.785	1	3611.785	586.322	.001
MAIN EFFECTS		477.436	6	79.573	12.917	.001
SEX		116.105	1	116.105	18.848	.001
SES		51.910	2	25.955	4.213	.015
STYPE		278.625	2	139.312	22.615	.001
CURR		76.030	1	76.030	12.342	.001
2-WAY INTERACTIONS		233.725	13	17.979	2.919	.001
SEX	SES	10.811	2	5.405	.877	.999
SEX	STYPE	3.559	2	1.779	.289	.999
SEX	CURR	3.901	1	3.901	.633	.999
SES	STYPE	33.458	4	8.364	1.358	.245
SES	CURR	45.665	2	22.833	3.707	.024
STYPE	CURR	172.949	2	86.474	14.038	.001
EXPLAINED		4322.947	20	216.147	35.088	.001
RESIDUAL		14488.494	2352	6.160		
TOTAL		18811.441	3272	7.931		