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ABSTRACT

A number of the working papers produced for the guidance of the staff of the Australian Science Education Project during the development of instructional units for secondary school science are included in this package. Topics covered range from a discussion of the implications, for curriculum writers, of the research on cognitive development to checklists for stages in the development of a unit. The titles of the working papers are: "Ways of Dealing With Subject Matter According to the Stages of Development of the Children," "The Structure of a Typical Unit," "Contents of Teacher's Guides (First Trials)," "Units to be Developed," "Steps in the Development of a Unit," "Preamble to the Aims," "The Aims of the Australian Science Education Project," "The Main Ideas to be Developed in ASEP Materials," "Use of the Inquiry Approach," "A Taxonomy of ASEP Objectives," "Preparation of Second Specifications of a Unit," "Re-allocation of Units for Development," "A Plan for the Second Trials of Units," and "Checklist for Unit Development and Production." [Not available in hard copy due to marginal legibility of original document.] (AL)

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Australian Science Education Project

WAYS OF DEALING WITH SUBJECT MATTER ACCORDING TO THE STAGES OF DEVELOPMENT OF THE CHILDREN

Preamble

This paper has two sections. The first is concerned with general principles for dealing with subject matter. These principles have been derived from Piaget's theory of intellectual development and apply at all stages of the child's development. The second section deals with features of children's thinking at each of the stages defined for the ASEP materials.

Inhelder and Piaget (1958) have described the behaviours and abilities of children with respect to logical thinking and have specified three main stages in development - preoperational, concrete and formal. The age range of each stage has been stated, for Geneva children, as follows:

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

The children for whom ASEP will produce materials fit the age groups stated by Inhelder and Piaget for the concrete stage (7 - 11/12 years) and the formal stage (12 - 15+ years).

There has been little research designed to validate Piaget's findings on the transition from the concrete to the formal stage but the available evidence suggests that the transition is a gradual one and takes place at different ages for separate individuals and for different subject matter areas. It appears that for Australian children the age of attainment of formal thinking could be later than that suggested by Inhelder and Piaget. The findings of Lovell (1961) led him to conclude that the sample of children tested by Inhelder and Piaget (1958) must have consisted of 'able' children as he found that the British children tested reached formal thinking at a later age than the Geneva children. Unpublished research on Australian children by Page (ANU) and Dale (ACER) supports Lovell's conclusion.

Although there has been little validatory research at the concrete formal transition there has been a great deal of research on the early concrete stage. While this research has revealed some variations from Piaget's claims, in general it has confirmed his claims rather than refuted them and has led to strong support for Piaget's theory as a basis for curriculum development. Although his theory has not been comprehensively tested at the concrete-formal transition the available evidence is sufficient to justify the adoption of

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Inhelder and Piaget have distinguished two sub-stages in formal thinking. In the first sub-stage there is systematic thinking and a large degree of freedom from the need for 'concrete props' but formal thinking is not fully developed until the second sub-stage which begins at about 14-15 years. They have used as their criterion for success that 75% of a given age group demonstrate the relevant ability.

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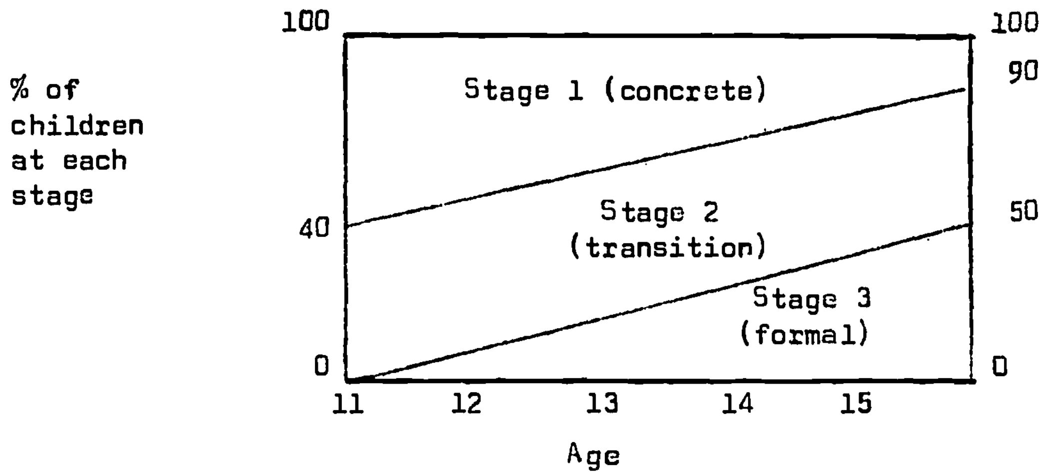
In accordance with the above, it is proposed that the Project should develop materials to suit children at three stages of development:

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.

The Project will assume the following pattern of change, as a working model. The figures quoted have been derived from unpublished research by Dale.



High priority must be given to the preparation of tests for determination of the stages of thinking of the children who will be using ASEP materials according to the criteria described below. These tests can be used initially to modify the model to fit existing conditions better.

GENERAL PRINCIPLES FOR DEALING WITH SUBJECT MATTER

The following principles have been derived from Piaget's theory of mental development and are adapted from Ginsburg and Opper (1969).

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

The child's thought processes can be very different from those of adults. It is not valid to generalize from what the adult finds simple. Curriculum materials can be developed at a level at which children are believed to function but the ultimate success of the materials rests with the teacher who can observe each child, discover his level of language and of thought and modify the child's education experiences accordingly.

2 A major source of learning is the activity of the child

Children must be given the opportunity to try out things to see what happens, manipulate things, manipulate words and symbols, pose questions, find their own answers, compare and reconcile their findings with those of other children.

At all stages of development activity in observing and manipulating actual objects or situations is essential. By Stage 3 (the formal stage) this kind of activity can be considerably reduced but it is still important as a foundation for thinking. Purely verbal learning can lead to very distorted or superficial ideas. Social activity, whereby children discuss findings and opinions with others leads to understanding at the verbal level and supplements physical activity. Children should be encouraged to talk, share experiences and argue.

3 <u>Classroom materials should be tailored to the needs of individuals and should present moderately novel situations</u>

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 met are moderately different from what is known - too great a difference can be discouraging and too small a difference lacks challenge.

4 <u>Children should be given considerable control over their own learning</u>

The normal child is eager to learn. He should be given a rich environment containing many things potentially of interest. He needs a teacher who is sensitive to his needs, who can judge what materials will challenge him, who can provide help when he needs help and who has faith in his capacity to learn.

<u>FEATURES OF CHILDREN'S THINKING AT EACH STAGE</u>

The following descriptions of abilities at each stage have been derived from Inhelder and Piaget (1958), Wallace (1965), Flavell (1963) and Lovell (1961). In many instances there is a need for more experimental evidence to support the statement and it will be necessary to check the validity of the statements during the trials of the ASEP materials.

Features of thinking	Comment on applications
1 <u>Need for concrete situations</u>	
<u>Stage 1</u>: Can solve problems involving concrete situations where actual objects can be observed and manipulated. Judgement is based on what a situation really is, rather than what it appears to be. Not dominated by perception so can, for example, cope with optical illusions or describe collections of objects as viewed from various directions without having to actually view them from those directions. <u>Stage 2</u> Can extend a little from actual situations into a consideration of possibilities. Fall short of consideration of all possibilities in very abstract situations.	At Stage 1, observations should be directed, using actual specimens and objects, and inferences drawn should be closely related to phenomena actually observed. At stage 2, considerations of possibilities can be included but the possibilities considered should then be presented in concrete form. At stage 3 it is desirable that some concrete experience be given, either prior to considering abstract situations or in representation of some of the possibilities considered. At this stage children should be able to generate their own list of possibilities in abstract situations.

Features of thinking	Comment on applications
1 (contd.)	
Stage 3 Not tied to concrete situations - can solve theoretical or abstract problems by manipulating words and/or symbols. Judgement takes into account all possible situations, not just what can be observed and manipulated. Reality is just a sub-set of possibility	
2 Desire to completely solve a problem	
Stage 1 Do not seek to completely solve a problem for the sake of obtaining a complete explanation or solution but can often solve a concrete problem by trial and error if required to do so. Often satisfied with causal explanations. Can explain in terms of scientific causality. Seldom revert to mystical or animistic explanations.	
Stage 2 Seek explanations that satisfy findings but do not persist with the search for all possible combinations of variables in order to establish a necessary relationship. Confidence in validity of deductions not fully established.	At stages 1 and 2 the problems to be investigated will usually have to be stated for the children or specific guidance will need to be given. Similarly they will need guidance in checking the adequacy and validity of conclusions drawn from attempts to solve a problem.
Stage 3 Seek to establish a necessary relationship and a complete explanation by examining all possible relationships. Completely confident in validity of deductions.	
3 Ability to isolate variables and test them systematically	
Stage 1 Can eliminate simple contradictions in explanations but have difficulty in finding elements common to several relationships or situations. Can isolate some of the variables present in a problem situation but have difficulty in separating relevant from irrelevant information.	At stage 1 systematic construction and testing of possibilities should not be expected of children but they should be able to eliminate contradictory explanations. At stages 1 and 2 help will have to be given to enable children to test all possibilities and to realize that they have done so. Assistance in identifying relevant variables will be necessary.

	Features of thinking	Comment on applications
3	(contd.)	
	<u>Stage 2</u> Can isolate variables present and separate relevant from irrelevant information by testing systematically. May not test all possible relevant combinations.	
	<u>Stage 3</u> Can isolate variables and test systematically using all possible combinations as far as is necessary to establish a proof.	
4	<u>Ability to control unwanted variables</u>	
	<u>Stage 1</u> When attempting to find a solution tend to consider one factor at the time and ignore all others i.e. deal with variables by eliminating or ignoring them, rather than by neutralizing (controlling) them (i.e. by use of scientific control procedures).	Stage 2 is the earliest stage at which some understanding of the use of scientific control of unwanted variables can be expected and, hence, is the earliest stage at which this procedure should be introduced. It is unlikely that children at stage 2 will be able to design their own experiments making use of control procedures, unless they do this by following a set of rules (see 5 below).
	<u>Stage 2</u> When attempting to find a solution, fluctuate between elimination of unwanted variables and control by neutralization.	
	<u>Stage 3</u> When attempting to find a solution, control irrelevant or unwanted variables by neutralizing them i.e. by holding them constant.	
5	<u>Ability to develop rules and procedures and models</u>	
	<u>Stage 1</u> Can carry out activities using specified procedures, rules or techniques in handling actual objects or situations. Can devise own procedures, etc. but limited to concrete situations. Can develop and use concrete models.	Instructions at stage 1 should be clearly stated and involve concrete situations. Abstract models can be introduced at stage 2 but it is unlikely that children will be able to develop their own models before stage 3.
	<u>Stage 2</u> Can extend the use of procedures beyond the range of situations that can be experienced but are still dependent on concrete situations to some extent. Can develop models but are tied to reality.	

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	Features of thinking	Comment on applications
5	(contd.)	
	<u>Stage 3</u> Can develop own rules and procedures, for use in concrete and abstract situations. Can understand and develop theoretical models.	
6	<u>Ability to classify information</u>	
	<u>Stage 1</u> Can classify into various categories. Can classify the same objects in different ways successively and can form a hierarchical classification system i.e. classify in several categories simultaneously.	Classificatory procedures can be used from Stage 1 onwards.
7	<u>Ability to establish series</u>	
	<u>Stage 1</u> Can rank in series, can interpolate within the series and extrapolate beyond it within the limits of real situations.	Ranking, interpolation and extrapolation at stage 1 should be limited to concrete situations.
8	<u>Ability to establish relationships between variables</u> (i.e. handle proportion)	
	<u>Stage 1</u> Can establish relationships between two series, involving direct variation with two variables only and in concrete situations.	The abilities listed should be taken into account when dealing with the types of relationship concerned. An attempt should be made to check the extent to which this categorization of abilities is accurate.
	<u>Stage 2</u> Can establish relationships between two variables, involving inverse variation. May be able to relate three variables in concrete situations. e.g. $d \propto \frac{m}{v}$	
	<u>Stage 3</u> Can establish relationships between three or four variables e.g. discover the rule for balancing a rod by changing the weight or its distance from the pivot and on either side of the pivot.	
9	<u>Ability to deal with probability and correlation</u>	
	<u>Stage 1</u> Accept chance fluctuations and endeavour to search for causes. Can set boundaries for the fluctuations but may not realize that they are distributed approximately according to a normal distribution curve.	This categorization of abilities should be taken into account where statistical interpretation of data is required. It sets a lower limit for introduction of some ideas.

	Features of thinking	Comment on applications
9	(contd.) <u>Stage 2</u> Realize qualitatively that chance fluctuations are approximately normally distributed. Endeavour to establish relationships in terms of confirming cases and express as a probability i.e. <u>confirming</u>, rather than a total cases correlation. <u>Stage 3</u> Establish correlations by relating the confirming cases to the non-confirming and to the total number of cases i.e. <u>confirming - non-confirming</u> total	
10	<u>Understanding of number and measurement</u> <u>Stage 1</u> Understand number and can perform simple calculations with understanding. Understand the use of units in measurement and can devise own simple units.	Activities involving number and measurement can be introduced early into stage 1 materials.
11	<u>Ability to specify position</u> <u>Stage 1</u> Understand horizontal and vertical e.g. can draw water surfaces in containers. Can use and understand two perpendicular axes to locate points. Can understand direction and can read two-dimensional plans and maps. <u>Stage 2</u> Can use three-dimensional axes in concrete situations and can interpret three-dimensional concrete solids. <u>Stage 3</u> Can handle abstract applications of specification of position e.g. in dealing with three-dimensional mathematical problems.	It is suggested that three-dimensional specification of position can be introduced in stage 2 materials but it must be associated with concrete representation. (Some check should be made that this in fact can be done at stage 2.)
12	<u>Understanding of area and volume</u> <u>Stage 1</u> Understand area and its constancy in three-dimensional situations e.g. if a rectangle is made into a hollow cylinder. Do not comprehend volume i.e. do not realise its constancy when dimensions are changed e.g. when liquid is poured into a narrower vessel.	

	Features of thinking	Comment on applications
12	(contd.) Stage 2 Understand interior volume i.e. realize constancy of volume of liquids and plastic substances despite perceptual dimension changes. Can calculate interior volume with understanding. Stage 3 Understand displacement volume i.e. realize a solid displaces an equal volume of liquid.	The abilities listed refer to changes in volume of solids and liquids. It is not known how students react to changes in volume of gases under pressure or during chemical generation of gases. It is recommended that varied concrete experience of the latter situations be provided before abstract situations are considered. Abstract situations should not be dealt with before stage 3.
13	Understanding of density	
	Stage 1 Do not understand density. Realize that there is a difference which is related to weight and size in some way but cannot explain it.	Density is a stage 2 concept and should not be dealt with in detail before then. Even at stage 2, experience in handling materials of different densities should be given.
	Stage 2 Have some understanding of density in the form $D = \frac{m}{v}$ and in relation to concrete situations. Stage 3 Understand density fully, in the form of a specific gravity relationship and can calculate with understanding.	
14	Understanding of weight	
	Stage 1 Realize the constancy of weight where matter is conserved. Some children may revert to non-conservation in the face of apparently conflicting evidence.	Conservation of weight can be introduced early but before stage 2 there could be problems in the case of generation of a gas.
	Stage 2 Fully understand conservation of weight.	
15	Understanding of time and time intervals	
	Stage 1 Can measure time intervals. Understand intervals up to a year but have inadequate grasp of longer intervals. Little understanding of continuity of time. Under estimate time intervals longer than seconds.	Estimation of time intervals is not easy for children. Devices or instruments for measuring time should be used. Consideration of longer time intervals and sequences is better left to later stages. Periodicity is probably a stage 3 concept.
	Stage 2 Better grasp of more abstract time words e.g. recent, eternal, B.C. Under estimate time intervals. Some understanding of historical sequences (time lines).	

Features of thinking	Comment on applications
15 (contd.) Stage 3 Understand historical time, dates, chronological sequences.	
16 Understanding of speed Stage 1 Understand speed and velocity.	

THE EXTENT TO WHICH ATTEMPTS SHOULD BE MADE TO EXPEDITE THE DEVELOPMENT OF THE CHILD FROM STAGE 1 TO STAGE 3

The available evidence suggests that it is possible to expedite development within rather narrow limits. The provision of experience and practice of certain kinds has been successful with children regarded as already close to the transition from one stage to the next. Explanation of and experience in the use of the type of logical reasoning involved in a given situation has had some success in facilitating development in the particular ability concerned.

It is suggested that, while the type of experiences provided in ASEP materials may assist in the development of some children through the stages described, the Project should not set out to deliberately devise experiences to facilitate development through the stages.

REFERENCES

Dale, L.G., Analysis of a Problem Solving Task, unpublished M. Ed. thesis, Melbourne, 1970.

Flavell, J.H., The Developmental Psychology of Jean Piaget, Princetown, New Jersey, van Nostrand, 1963.

Ginsburg, H. and Opper, S., Piaget's Theory of Intellectual Development: An Introduction, Englewood Cliffs, N.J., Prentice-Hall, 1969.

Inhelder, B. and Piaget, J., The Growth of Logical Thinking from Childhood to Adolescence, New York, Basic Books, 1958.

Lovell, K., A Follow-up Study of Inhelder and Piaget's 'The Growth of Logical Thinking', Br. J. Psychol., 1961, 52, 143-55.

Page, S., Transition from Concrete to Formal Operations, unpublished paper presented at conference, Canberra, February, 1970.

Wallace, J.G., Concept Growth and the Education of the Child, N.F.E.R., 1965.

ASEP

THE STRUCTURE OF A TYPICAL UNIT

1 In the following, the terms core, core-development and research activities will be used for want of better terms. These will be replaced as soon as better terms have been found. Suggestions for more meaningful headings are very welcome.

2 Many units will consist of a core of work to be covered by all students which leads to a tentative generalization or gives practice in certain skills.

The average student should not need more than five periods (40 mins.) to cover the core activities which contain the basic information and facilitatory techniques which guide students to carry out investigations efficiently. The core will be followed by core development activities.

3 Remedial activities can be used to assure that the core has been internalized by all students. At the other end of the spectrum of activities every effort must be made to encourage and extend gifted children.

4 The core development activities are to be considered at least as important as the core material and are integral to the learning experience. They are not there just to occupy the time of the bright child. Every student should experience some of the optional activities, which should include new, interesting and open-ended investigations.

5 The additional work can be considered in three main categories:

5.1 Remedial and preparatory activities to assist students to become fully operational members of their peer group by supplying additional information and opportunities to practice skills.

5.2 Core development activities to broaden experience within the range of generalizations and techniques already presented or to allow study in greater depth of generalizations, etc. already presented.

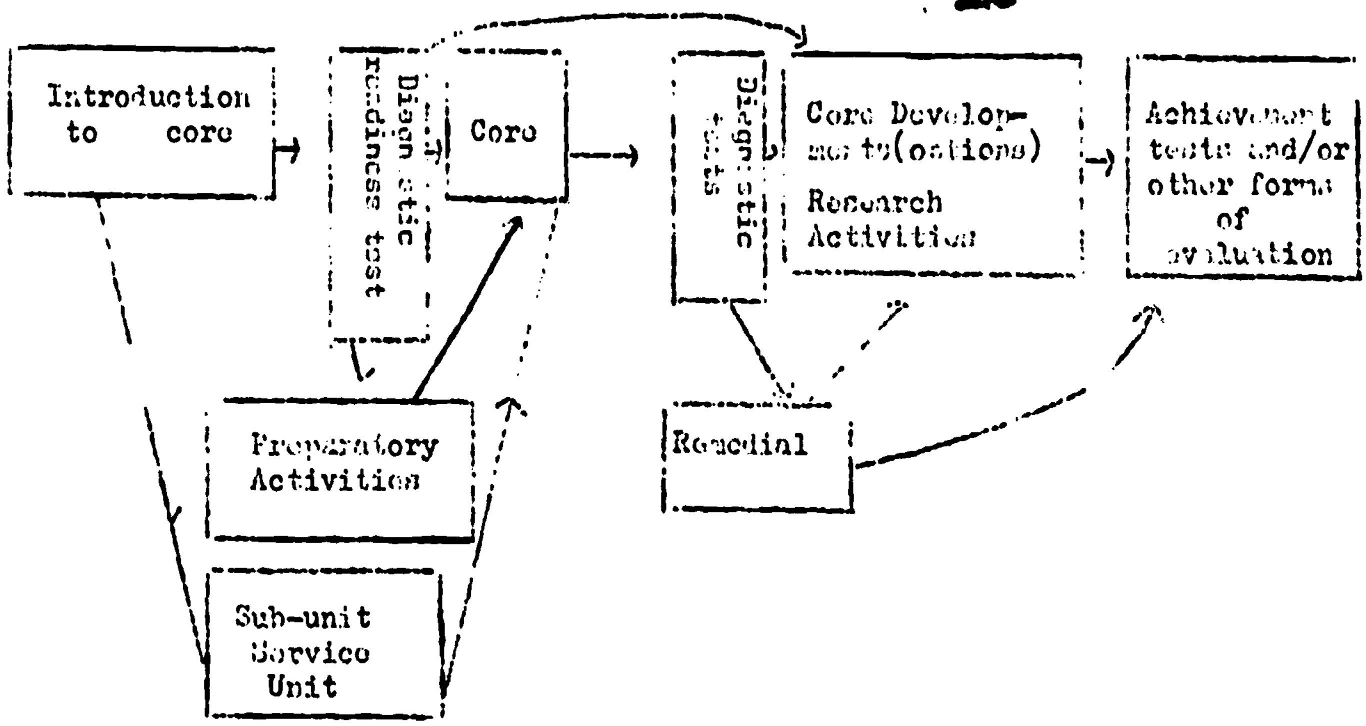
Some of these activities will extend the range of generalizations and techniques beyond that presented in the core.

5.3 Research activities which are always open-ended. No guidance beyond the initial idea to be followed up will be given. Occasionally the research could be completely initiated by the student.

6 Tentatively, a duration of nine periods is anticipated for core developments, and three periods for the start of research activities which may well be carried on in the students out-of-school time.

Three periods may be needed for tests and remedial activities. These total to 20 (40 min.) periods i.e. about 4-5 weeks of teaching time. It is likely that some units will be shorter, about two weeks, others longer.

7 A plan that could be followed is represented by the following diagram:



8 The introduction should be brief. It could be exposition by the teacher, film, picture, newspaper article, etc. designed to catch attention and provide background for the core studies.

9 Sub-units (service units) are mainly intended to convey concepts and principles, which are necessary pre-requisites for more than one unit. The project policy of complete flexibility and freedom of choice precludes the certainty that any one given area of knowledge will have been 'covered' by all students at any one particular time. If a teacher is aware of such a deficiency a sub-unit can be used as introduction to the core of the main unit. Alternatively, testing prior to starting on the core of a unit will reveal a lack of knowledge of some students and a sub-unit can then be used as a preliminary remedial activity.

10 Although many units will be structured following the above plan, others will not lend themselves to this method of treatment and will contain few options and an extended 'core'.

11 The outcomes of the diagnostic readiness test, which reveals how much of the work covered by the unit is already known by the student, can be used to direct the student

11.1 to further preparation to make the student ready for the work to be covered, followed by the core,

11.2 directly to the core,

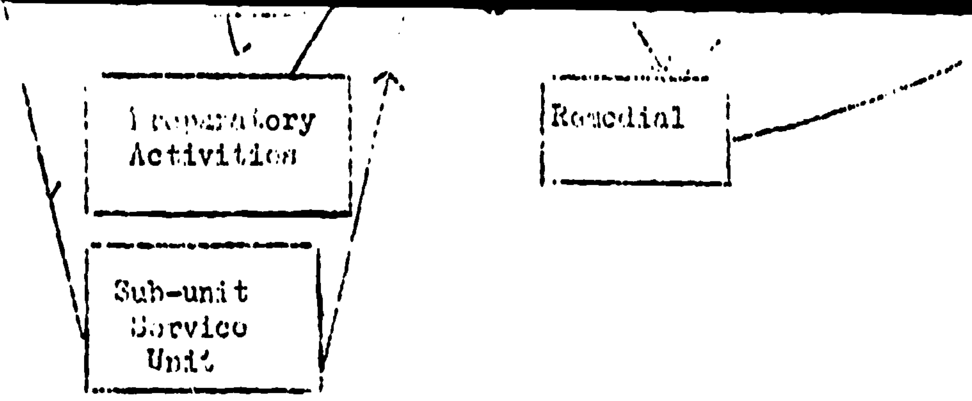
11.3 in some cases by-passing the core, to core development

12 The diagnostic test at the end of the core can be used to direct students either to core development or remedial activities.

REMEDIAL AND PREPARATORY ACTIVITIES

13 The need for remedial or preparatory activity should be diagnosed by very carefully designed tests which are given frequently and which must not be used for assessment purposes. These tests could be of three types.

13.1 Pencil and paper tests which are self-scoring and with each [illegible] activity should be suggested (e.g.



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- 13.1 Pencil and paper tests which are self-scoring and with each wrong answer a remedial activity should be suggested (e.g. PSSC tests and aids). This will ensure that a fairly large proportion of a class will be involved in such activities and hence minimize the sense of failure for some.
- 13.2 Practical tests consisting in 'handling' of equipment which is observed and rated by the teacher or a student who then indicates the type of remedy.
- 13.3 Cognitive preference items. Children who opt for theory may be directed to experimental work and vice versa.

14 Remedial activities will be mainly necessary in those cases where

14.1 important techniques, which are essential to later activities or units have to be acquired, e.g. simple mathematical skills such as proportionality, power of ten notation, interpretation of graphs or manipulative skills such as using a microscope.

14.2 constructs have to be conceptualized to make further work meaningful, such as conservation of Mass, Mendelian inheritance, homeostasis.

Examples of remedial activities

15 Linear programs on specific knowledge
Programmed instructions on practical techniques
Mathematical examples of increasing difficulty
Instructions for reading certain information
Instructions for carrying out directed observations
'Word' games
Film loops
Note: Whatever the activity, no exact replica of previous work should occur.

16 Desirable features of such activities

16.1 make good use of non-verbal illustrations
16.2 can be easily understood by the students concerned
16.3 short but effective
16.4 must be easily accessible to students
16.5 interesting and attractive.

Research Activities

17 Suggestions for such activities (not in any specific order):

17.1 Improve a given piece of equipment e.g. make a better micro-balance.

17.2 Design and construct a working model e.g. build a crystal set or a Galilean telescope.

17.3 Design an experiment to test a hypothesis e.g. does a drop of cold water settle turkish coffee.

17.4 Observe and record changes in plantsover a long time.

17.5 Observe and record the behaviour of a pet or wild animal(s).

17.6 Reproduce a "classic experiment", e.g. Benjamin Franklin's 'Leyden' jar and chimes, Oersteds expt.

17.7 Study one example of controversy in the history of development of ideas and act it out as a scene e.g. a meeting between Priestley and Lavoisier, or give a lecture à la Rumford, hammering thin lead foil rather than boring cannons; or write a 'playlet' which shows the work of a scientist against the contemporary background e.g. yellow fever and the Panama canal.

17.8 Plan and conduct a survey of technical applications of a scientific principle e.g. transistors.

17.9 Completely free and suggested by students, as long as there is a connection with the topic under discussion.

17.10 Read about the development of ideas, work of scientists, etc.

17.11 A group is responsible for 'Science News(scrap book, summaries or precis of articles read.

17.12 Linked with other subject areas.

Desirable features of Core Developments

18 Provided the choice of activities is sufficiently large, students can follow their preferences and thereby be strongly motivated to explore materials as well as the use of libraries and other resources. To facilitate choice by students, each activity should be clearly described in a detailed way, and an index should indicate the available choices.

19 Group work is encouraged, where co-operation between the highly intelligent and the dexterous, but not so intelligent, child may produce mutual respect.

20 By crossing subject boundaries the essential unity of all human endeavour can be shown.

<u>Notes on the writing of background materials in particular, the history of science.</u>

21 Background booklets for the use of students and teachers will have to be written for some of these activities and reference list must be supplied. The teacher must be given sufficient confidence to admit that he does not know everything and has to 'find out' himself or ask the student to do so.

22 Where-ever possible, interesting and/or amusing anecdotes should be included into biographical sketches, which should stress that "Scientists are people". Biographies per se are usually boring, and children will not read them.

23 Theories and discoveries should be presented against a back-ground of contemporary thinking, e.g. Kepler was an Astrologer, his mother accused of witchcraft, or, the popularity of weightless fluids - calories, phlogiston, so that the magnitude of progress can be seen.

24 In general, descriptions should be incorporated into the appropriate unit, e.g. electrolysis - extraction of some metals, story of electrolysis. Occasionally it may be possible to duplicate a classic experiment, e.g. Oersted's expt.

25 A list of books and magazine articles should go with the units
a) to be read by interested students, who then report to the class
b) to be read by the teacher who can tell the "story" to the class
e.g. Science Study Series: Pasteur, Rumford, Faraday, Stories from Science, Nuffield books, Asimov's books.

26. Some background books may have to be written, consistent with ASEP aims, with unobstructive emphasis on the attitudes which we want to develop, e.g. to show that preconception hinders progress.

27 Articles from current magazines, such as 'Scientific American', should be rewritten in simplified language.

CONTENTS OF TEACHER'S GUIDES (FIRST TRAILS)

1. This document should be read in conjunction with 'Recommendations for Teacher's Guides', GER/LD/VK, 17 April 1970.

2 The approach adopted should be one of suggesting ways in which the unit or parts of the unit can be handled in the classroom rather than prescribing ways in which it should be done.

3 The use of a personal approach by the use of 'you' and 'we' rather than an impersonal one, e.g. such and such can be done, is the decision of the developer, at this stage. It may be advisable to adopt one approach or the other for second trial materials.

Each teacher's guide should contain the following information, in the following sequence.

4 Statements of the recommended

4.1 stage of development of children using the unit.
4.2 reading age (or level) of children using the unit.
4.3 duration, in 40 minute periods, of the unit. A separation of duration of 'core' from duration of the whole unit could be useful to teachers.
4.4 preparation time needed by teachers.
4.5 place in the course of study, in terms of pre-requisites and possible follow-up.
4.6 time of the year when the unit should be used.

5 A statement of the general purposes of the unit. This should be short but sufficient to give teachers a good indication of what the unit is about. Detailed objectives should not be given here but can be listed in Appendix I, to which attention should be drawn.

6 Where it is felt desirable that an explanation of the science involved in the unit be provided for teachers with inadequate science background in that particular area, such explanations should be given in Appendix 2. Attention to Appendix 2 should be drawn by a note following the purposes.

7 A diagrammatic representation of the various parts of the unit and how students might work through them.

8 A list of all equipment and materials needed for the unit. This list should include numbers required of each type and, for equipment and materials not normally available in schools, sources of supply and approximate cost.

9 Immediately following the list of equipment and materials, instructions for making equipment or reagents or preparing materials, together with suggested precautions for storage and handling of certain hazardous items.

10 A list of audio visuals useful in using the unit. Catalogue numbers and sources should be shown.

11 A list of references appropriate to the unit. Approved style should be used.

12 Comments, hints and instructions of use to teachers using the unit. Such items that would be known to many teachers but useful to a few should be placed in an appendix to which attention should be drawn. Some items should be placed adjacent to relevant student materials rather than in a separate teacher's guide booklet.

13 Answers to questions asked in the text, sample collections of data and similar items to assist teachers. As for comments, etc., some of these items should be placed adjacent to relevant student materials.

14 The above points are stated in the interests of consistency among teacher's guides rather than as prescription or restriction on what might be included. It is desirable that a teacher's guide be adapted to suit the unit for which it is written and that it be, first and foremost, a useful document for teachers.

15 A balance must be maintained between brevity (teachers do not have time to read lengthy descriptions) and clarity (not so brief that it is difficult to follow). To this end, material that could be useful but does not appear to be essential for the majority of teachers should be placed in the appendix.

Document 10

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DEV/LEH/PC
17 January 1972

Australian Science Education Project

UNITS TO BE DEVELOPED

The following list has been prepared for general information. The number of units is the number that can be developed within the limits of the available time and resources.

The outlines given indicate the general scope of each unit. More specific information can be obtained from the unit specification and/or the trial version. The key below indicates the extent of development of each unit.

x	1st Specification only
xx	1st & 2nd Specification only
xxx	1st, 2nd Specification, 1st trial version
xxxx	" " " , and National trial version.

STAGE I UNITS (essentially Grades 7-8)

101 Messengers (xxxx)

Information is gained about our environment by reception through the senses. Information is received by observation of changes and by interactions with the environment. The extent and reliability of the information are limited by the sensitivity of our senses and our interpretation of our observations.

102 Mice and Men (xxxx)

Students are entrusted with the care of mice. By investigating mice they learn some of the defining characteristics of mammals and become aware of the similarities between humans and mammals, particularly mice. Observations are made of growth patterns, reproduction, food requirements and preferences, and behaviour.

103 SCIENCE AND SAFETY (xxxx)

A science room can have hazards which are not normally a part of the students' experience. These hazards are investigated and ways of minimising them are discussed and practiced.

Some techniques for using apparatus are given. The options are designed to make students aware of the dangers which they can meet in everyday life.

The students are encouraged to become safety conscious and it is hoped that sensible precautions will be taken in all their activities.

104 CELLS, THE UNITS OF LIFE (xxxx)

Cells from a variety of plant and animal tissues are prepared and examined microscopically. Cells are considered as living units in which chemical reactions take place. Growth in living things is related to growth and division of cells. Models of cells and tissues are made.

105 SOIL (xxxx)

Students examine a soil sample in order to see that soil is a mixture of living organisms, decaying organic matter, air, water and minerals. Soil forming influences are studied briefly and the importance of soil in relation to food production is dealt with. Some attention is given to soil conservation, the use of clays and other constituents of foundations.

106 MALES AND FEMALES (xxx)

This unit has been written to help students learn about human sexuality and reproduction by: teaching them some words they can use to describe sexual organs and functions; and explaining the basic ideas of fertilization, parental care, and the reproductive cycle. Information on reproduction in other organisms is provided in the options.

107 PIGMENTS AND ACIDITY (xxx)

This unit introduces students to the phenomena of acidity and its detection with plant and synthetic dyes. Dyes are also used in chromatography and fabric dyeing. The options emphasize the importance of acidity in the environment.

108 PUSHES AND PULLS (xxxx)

This unit is a modification of the ISCS treatment of force. The unit aims to introduce students to the range of forces acting in the environment - their detection and measurement.

109 SIGNALS WITHOUT WORDS (xxxx)

Members of groups interact non-verbally and these interactions are important in establishing relationships between group members and in determining the group structure. Non-verbal communication includes facial expressions, gestures and combinations of these.

110 MADE TO MEASURE (xxx)

The unit aims to make the student aware of the many situations where measurement is important either for communication or for clarifying observations. Some attention is given to the problems and limitations of measurement.

111 ELECTRIC CIRCUITS (xxx)

The unit aims to introduce children to electrical circuitry. Particular attention is paid to safety. Options deal with the applications of circuitry in the environment, and some of the history of man's knowledge of electricity.

112 LITTLE BOXES (xxxx)

One aspect of man's adaptation to his environment, namely the almost universal and age-long practise of obtaining shelter, is studied in this unit. Man's need for protection, warmth, insulation, light, space and privacy are noted, and opportunity is provided for studying how houses and urban areas can be designed to supply these requirements. Attention is also given to the development and testing of construction materials and the production and utilization of commonly available materials. Opportunity is also provided for investigating urbanization, garbage production and disposal.

113 PLANTS (xxxx)

This unit is an investigation of the diversity of plant types and how the variety of plants changes from one locality to another. Students are encouraged to grow their own plants at school and study the different groups of plants. These observations provide the basis for the options

114 MINERALS AND CRYSTALS (xxx)

Crystals are grown in the laboratory and their properties are compared with the properties of common rock forming minerals. Students see that crystalline rocks are agglomerations of minerals. The unit concludes with students studying the Australian mineral industry, gem minerals, minerals with unusual properties etc.

115 WATER (xxxx)

The unit examines the widespread existence of water in nature. The dissolving power and chemical reactivity of water are studied together with several physical properties. Options are keyed to the hydrological cycle and are designed to illustrate the various components of the cycle, including man's use of water. Emphasis is given to Australia's use of water resources.

116 ROCKS FROM SEDIMENTS (xxxx)

The core theme is 'erosion and levelling of the land', which leads to a study of weathering, transportation, deposition and formation of clastic sedimentary rocks. The unit concludes with options on weathering, rates of erosion, the formation and use of other types of sedimentary rocks such as; halite, gypsum, limestone, coal and phosphate rock.

117 ENERGY AND CHANGE (xxxx)

Students become aware that the process of change is accompanied by the transfer of energy. In the options students investigate a number of these energy converters.

118 INSECTS (x)

A study of the life cycle of one species of insect (or other arthropod). Stages of growth, metamorphosis, response to stimuli, reproduction, social behaviour. No particular type of organism has yet been selected but those under consideration as suitable for classroom use are: grasshopper, ant, termite, fly, mosquito, field cricket, earwig, cockroach, slater (wood-louse).

119 THE SCIENTISTS (xxxx)

This is a brief introductory unit designed to answer the question -'What is a scientist?'

STAGE II UNITS (essentially Grades 8-9)

201 MICROBES AND MAN (xxxx)

Man and microbes are interdependent. This concept of interdependence is developed through activities in which students observe the cyclic processes of growth and decay resulting from microbial action. Students make bread, yogurt or cider, preserve foods, and observe the effect of decomposers (largely bacteria) on organic and inorganic materials. The potentially harmful effects of some microbes is considered from an historic view point, and the need for elementary hygiene is also considered.

202 STICKING TOGETHER (xxxx)

The unit examines the attractive force that exist in materials. Through activity students are led to formulate a particle model in which the particles experience inter-particle attractive forces. The importance of these forces is examined in processes such as detergency, solution and lubrication.

203 LIGHT FORMS IMAGES (xxxx)

Students investigate the nature of images formed by light. Extensions include the photographic process, and a number of optical instruments.

../4

204 MAKING LIFE EASIER (x)

In this unit simple machines are constructed and examined. Efficiences are considered and the idea of energy transfer (power train) is developed. Complex machines are looked at to discern simple machines.

205 SKIN AND CLOTHES (xxxx)

The unit examines some physiological aspects of skin, and how these are affected by clothing. This leads to an examination of the physical properties of clothing materials, and the areas where the functions of skin and clothes overlap. Some consideration is also given to the distinction between the psychological and sociological aspects of clothing.

206 ENERGY FOR LIFE (xxxx)

The essential idea of the unit is that food is used for growth and, by the process of respiration, for energy release. Options deal with measuring the energy value of foods; testing various foods (qualitatively) for major nutrients; the immediate source of energy for muscular contraction; the role of enzymes in digestion; absorption and transport of nutrients; the function of the heart and the effect of exercise on cardiac activity; anaerobic respiration in plants and man; breathing and gaseous exchange; the necessity for a balanced diet; temperature regulation in man and other homeotherms; and obesity.

207 DIGGING UP EVIDENCE (xxxx)

Sequences of stratified rocks form a book, which projects the reader back in time. Students by comparing fossils vertically and horizontally in strategraphic columns learn to appreciate the gradual evolution of life. The unit also introduces the geologic time scale.

208 LIFE IN FRESHWATER (xxxx)

The students learn about the great variety of living things in freshwater and their interdependence. An excursion to freshwater is recommended. The students set up aquariums, raise microscopic animals, investigate freshwater life further, and learn about pollution and sewage treatment.

209 AUSTRALIAN LANDSCAPES (xxxx)

This unit takes students on a tour of Australia. It examines by means of experiments, photographs and maps 'the forces below and forces above' which have shaped and sculptured Australia's land surfaces, as well as the flora and fauna which grace them. Landscapes studied include mountain regions, karst topographies, desert landscapes and landscapes carved in layered rocks. Resource management and conservation are two issues referred to in the unit.

210 AUSTRALIAN SEASHORES (xxxx)

This unit studies the work of the sea on the coast by initially studying the reflection and refraction of water waves by objects placed in a ripple tank. Students deduce the events in the evolution of an embayed coast. The delicate balance which exists between organisms and their environment is explored. Man's interaction with the coast is examined with respect to exploitation of mineral deposits and the need for conservation.

211 WINDS AND WEATHER (x)

Differences in absorption of radiant energy by air, land and sea leads to the setting up of atmospheric convection currents. Simple experiments show that decreasing pressure and decreasing temperature cause moisture in the air to form droplets of water around objects such as dust particles and salt crystals. Satellite cloud formation photographs are studied to predict the weather.

212 THE EARTH (xxxx)

This unit gives students a broad knowledge of the earth. Students are told that man has not been to the centre of the earth but that he has been able to obtain information about the centre of the earth by studying volcanoes, earthquake waves etc. Students study continental drift, the earth's magnetism, the formation of igneous rocks etc. in the options.

213 MODELS (xxxx)

Through the use of a simple concrete model this unit develops an understanding of: the usefulness and limitation of a model; the existence of atoms and a discrete number of elements and how a large variety of molecules can be assembled from a limited number of elementary atoms.

214 CHARGE (xxxx)

This unit establishes the dual nature of electric charge and the nature of the interaction between electrostatically charged bodies. The existence of charges in solution is also observed and related activities include charge migration and discharge.

215 GIVE AND TAKE (x)

Students study the interaction of two magnetic fields, leading to the making of a simple motor. Options include electro-magnets; Oersted's experiment in its historical context, efficiency of a small motor in hauling up small loads. Bicycle dynamo following the chain of energy transfer. Generation on the large scale, including steam turbines (qualitatively).

216 SPREADING FORCE (x)

Pressure of solids and liquids (blood pressure, the heart as pump). Gas pressure and a kinetic model are an option for the better students. Buoyancy without a formal statement of Archimedes' principle. Liquids in motion. Stream lines.

217 SUPPORTING STRUCTURES

The strength of a structure depends on the arrangement of the constituent particles and on the magnitude of the forces between the particles. The core studies the conditions necessary for attainments of static equilibrium, while core developments examine a variety of structures to see what forces keep them in equilibrium. Structures studied include the human skeleton, building frames and bridges.

218 THE STORY OF OIL (xxxx)

This unit deals with the oil exploration, mining and refining, and the options examine the use of petroleum products in the modern world. Some attention is also paid to the problem of pollution.

STAGE III UNITS (essentially Grades 9-10)

301 HOW MANY PEOPLE? (xxxx)

The unit begins with student activities designed to make them aware of some of the changes to the environment which can occur as the result of individual action. Then follow activities and discussion which suggests that the more people there are the greater the changes which are likely to occur.

This leads to an investigation of populations and some of the factors which control population size.

Optional material deals with populations of micro-organisms; a case study of the red kangaroo; a comparison of city life with country life; world population growth; an opinion poll on what people consider to be the optimum size of a family followed by a discussion of some ways by which people may control the size of their families; and activities and suggestions designed to make the students aware of what they can do as individuals to minimise environmental pollution and the non-cycling of matter.

Much of the unit depends upon discussion based upon the fundamental fact that population size is determined by births, deaths, in-migration and out-migration.

302 TRAFFIC (xxxx)

People spend a considerable part of their time in vehicular or pedestrian traffic. The systematic study of traffic flow is based upon measurements, many of which students can make and analyse for themselves. Students can then investigate problems such as the effect of stopping distance on accident rates, safety features, collisions, queues, frictional force, intersections etc.

303 THE HUMAN MACHINE (xxxx)

The human body is compared with an artificial machine to establish the relationship between energy input and output as measured by energy value of food ingested and oxygen consumed. The range of individual differences of such parameters as muscular strength, power output, physiological response to physical exertion, stamina, sleep requirements, reaction time and perceptual acuity, is stressed. Options deal with sex differences in physical performance; change in fitness with age; design of machines, furniture, work benches and physical tasks in relation to muscular fatigue; design of instruments and controls; functional design of clothing, including footwear; causes and treatment of injuries of muscles and joints; the effects of drugs on the nervous system; effects of pollutants (including cigarette smoke) on lung efficiency, sensory deprivation and sensory overload.

304 GENETICS (xxxx)

After examining some inherited differences between themselves and others, students investigate the fundamental mechanism of inheritance as illustrated by a monohybrid mice cross. Options are concerned with intermediate and polygenic inheritances; individual uniqueness; sex determination and sex linkage; interaction between heredity and environment (as illustrated by twin studies); inherited diseases; mutation and mutagens; and the value of pedigrees in analyzing inheritance. Social implications are mentioned where appropriate.

305 BIG MOLECULES (x)

Simple carbon chemistry leading from simple molecules to macro-molecules. The development of the unit involves such ideas as chemical stability, electrical and thermal insulation,

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and polymerization. Techniques such as extrusion, welding, moulding, and casting are discussed. The production, and uses (including mis-uses) of a large number of polymers are considered.

306 METALS IN THE SERVICE OF MAN (x)

Man's use of raw materials. A number of important metals are considered in terms of source, mining, extraction, properties and uses. Topics discussed include redox reactions and electroplating, metallic oxide and ceramics, alloys and metals for construction, crystal structure, electrical properties including semi-conductors. The unit also present an opportunity for discussion of some of the problems of ecological balance and pollution.

307 SOLAR ENERGY (x)

This unit examines 'where the earth's energy comes from' and the balance of energy at the top and base of the earth's atmosphere. The insulatory function of the atmosphere is studied as is the effect of pollutants, atmospheric gases and clouds on the energy balance. Students are introduced to a brief study of absorption spectroscopy.

308 WHERE HUMANS COME FROM (xxxx)

The unit is designed to encourage students to seek evidence in an attempt to solve the problem of the origin of humans about which it is impossible to be conclusive.

Four possible explanations are outlined

- creation
- evolution
- spontaneous generation
- influence or habitation by extra-terrestrial beings.

A starter kit of reference books, pamphlets, magazines and suggested practical activities is supplied with the unit and no attempt is made to evaluate the different explanations. This is left for the students to do in the light of the evidence which they can obtain. Indeed it would be possible for them to arrive at a different explanation from those that were outlined in the stimulus material.

309 SYSTEMS (xxxx)

The unifying theme is input ⟶ processing ⟶ output. This is elaborated upon an examination of systems in which output becomes feedback which modifies input. Applications are made to several physical and biological systems (including interpersonal communication).

310 EVOLUTION OF CONTINENTS (x)

This unit is primarily concerned with long-time cyclic events, associated with mountain building and the formation of continents, with particular reference to the evolution of Australia. It ties together the work covered in many of the earlier units by completing the rock cycle. Continental drift is studied briefly.

311 THE UNIVERSE (x)

The theme of this unit is 'the key to the past and to the future'. Topics briefly studied in this unit include space exploration, life on other planets, nuclear fission and fusion, evolution of stars and the magnitude of the universe. Reference is made to the work of Australia, in the field of radio and optical astronomy. A booklet listing activities for student astronomers will accompany the unit.

../8

312 AUSTRALIAN ABORIGINAL ECOLOGY (xx)

This unit is designed to introduce students to the scientific study of the way of life of the Australian Aborigine.

The unit begins with a comparison of the energy requirements of the nomadic Aborigine living in his tribal society and man living in an industrial society. This part of the unit serves as an introduction to optional material.

The options deal with an introduction to the Dreamtime; Aboriginal art; Aboriginal technology; anthropology; site investigation; and puzzling aspects which still have no solution.

No attempt is made to give value judgments on the two types of cultures. These are left for the student to decide in the light of evidence presented.

401 A GUIDE TO ASEP (Teacher Education unit) (xx)

The main purpose of this unit is to give teachers information on ASEP materials, and to allow them to think about how these materials might be used.

Of the fifty units listed it is anticipated that present resources will prevent the development of the following six:

118 Insects
215 Give and Take
216 Spreading Force
217 Supporting Structures
310 Evolution of Continents
311 The Universe.

Document 11

DEV/LD/KR
14th September, 1970

Australian Science Education Project

STEPS IN THE DEVELOPMENT OF A UNIT

The development of a unit can be traced through a number of steps. Details of the total process, including the people involved and each step in the sequence up to publication, will be included in Project Newsletter 2.

Prior to the first trial, each unit appears in five written forms:

1 a brief statement of the main ideas to be included

2 first specification

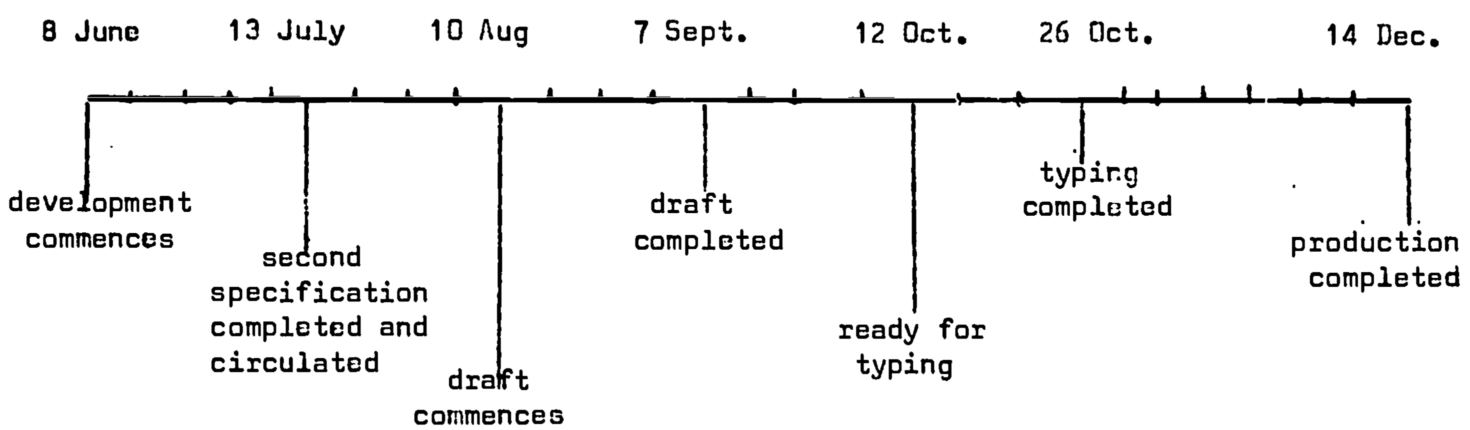
3 second specification

4 first draft

5 manuscript

In this paper, Unit 102 Mice and Men is used as an example to show what is involved in each of the first three written forms, and the time required for each stage.

1 Time Schedule for Unit 102 Mice and Men:



2 Brief Statement of the Main Ideas to be Included:
(This statement represents the first proposal from an Area Specialist that such a unit be developed)

Title: Rats
A comparison of rats and humans, through looking after and observing a family of rats or other small mammals. Growth changes, reproduction, food requirements and preferences, behaviour.

3 First Specification
(Once the initial proposal has been accepted, the Area Specialist produces the first specification as a statement of how the unit could be developed. This specification is read and discussed by all Area Specialists before it is accepted.)

Title: Rats (or mice, guinea pigs, hamsters, rabbits.)
Stage level 1
Length: approx. 20 40-minute periods.

Main Ideas:

The biosphere contains a large number of different species; an understanding of many of these, and their requirements, is essential to an understanding of the functioning of the biosphere, and thus to the way that humans affect it.

The intention is to create a situation vis, the need to care for, and observe, some small lively organisms. From this will arise many opportunities for study. Although perhaps none of these areas of study can be specified

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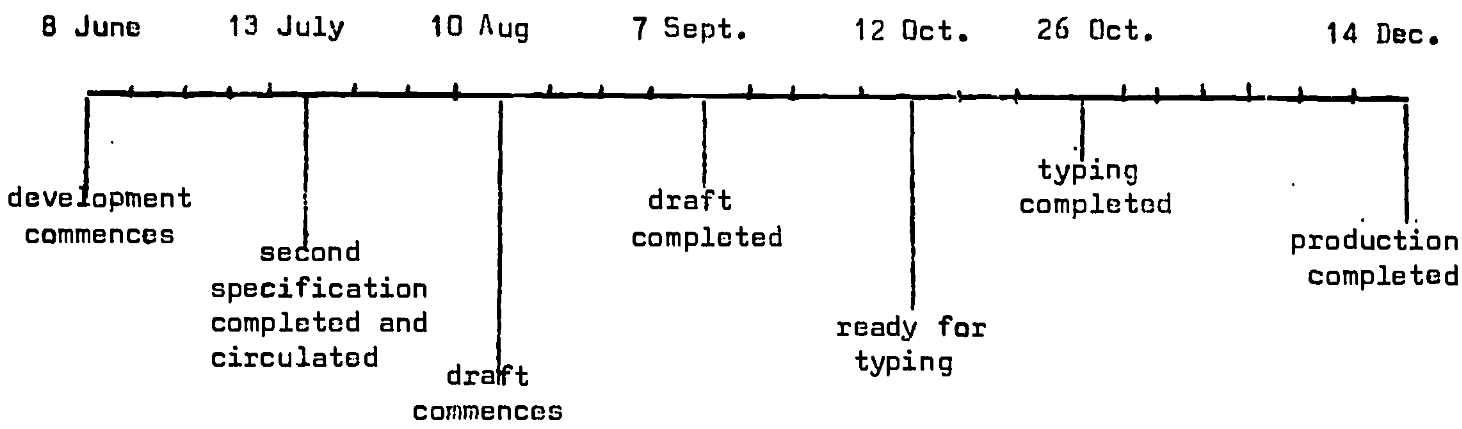

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The intention is to create a situation vis, the need to care for, and observe, some small lively organisms. From this will arise many opportunities for study. Although perhaps none of these areas of study can be specified as essential, and not all of them can be foreseen, they may include a selection from the following:

...2/-

1 Human characteristics, such as growth, nutrition, re-production, morphology and behavior can be studied by analogy, using small mammals. These can be manipulated and experimented with, whereas humans can not. Also, they exhibit changes e.g. - growth, far more rapidly, and so are more convenient to study.

2 The similarities of humans and rats can be studied, to provide evidence suggestive of a common ancestry, and the definitive features of the Class Mammalia.

3 The difference between rats and humans can be studied, to indicate divergence, and adaption.

4 There are definite requirements for organisms, of which the rat is an example:

- (a) Space - territorial behavior, exercise.
- (b) Temperature - nest construction.
- (c) Food and water.
- (d) Removal of waste products.

5 Organisms exhibit characteristic patterns of behavior, both instinctive and learned.

- (a) Food seeking behavior by infants, by adults.
- (b) Avoidance of danger by retreat.
- (c) Aggression - defence of territory or mates.
- (d) Nesting behavior and care of young.
- (e) Mating behavior.

6 The growth of an organism follows a sigmoidal pattern, which can be classified into infancy, youth, maturity, senility, adolescence. Growth parameters such as weight, tail length, can be measured regularly. The morphology also changes from stage to stage.

Brief Outline of Unit:

1 Overview illustrating some of the behaviors, requirements, growth, feeding of a range of small mammals - including some uncommon ones e.g. Tarsier, shrew.

2 **Discussion** of possibilities of investigation.-Group discussion (about 6 or 7 per group), followed by report to larger group e.g. class if necessary.

3 Presentation of necessary techniques:

- (i) There should be a reference book available, (NOT specifically for this unit), on care and handling of laboratory organisms (a comparative treatment). This would be required reading (perhaps some questions to which students must write answers).
- (ii) A cassette film showing techniques of handling (David Bruce, of ACER Psychological Services has agreed to demonstrate these techniques to put on an 8 mm film loop).
- (iii) Graphing and measurements techniques for weight and length -
  - (a) of rats.
  - (b) of food consumed.
  - (c) of water consumed.

4 Instructions and suggestions

- (i) For keeping records of body weight, and of tail length.

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(c) of water consumed.

4 Instructions and suggestions

(i) For keeping records of body weight, and of tail length.

(ii) For keeping records of food and water consumed.

(iii) Behavior investigations -

(a) Observation of movements, rest, feeding
(b) Response to stimuli
(c) Skinner box learning to push bar to release food
(d) Maze running
(e) Exercise wheel counting

(iv) Techniques of drawing to scale: morphology.

5 Student Investigations

The assumption is made that this unit can be continued for up to 3 months (1 term). The MDC developing this unit should investigate the organism most suitable for observing rapid changes of growth.

(i) The students should work in groups of 2 (or 3).
(ii) In a class of 30 to 40, about 15 sets of animals will be required.
(iii) A "set" of animals should include:
  1 adult male
  1 adult female (not pregnant)
  1 young male
  1 young female

Thus, growth may be observed in the juveniles, and reproduction by the adults. Thus 2 distinct sections of the life cycle can be observed simultaneously.

(iv) Various organisms i.e. - rats, mice, hamsters, guinea pigs, rabbits, may be studies by different student groups.
(v) During each typical 35 minute period, a definite time should be allocated to caring for the mammals, and making observations - perhaps 15 minutes at the start, reducing to 5 minutes later in the term.

6 Background study

For the remainder of the time in each period, at least for a month, assignments should be available, related to the organisms being studies. These assignments would basically be the collection of the information about mammals in general, and the particular mammal under study. Books should be selected, or a special book produced by ASEP, to supply information on mammals e.g. - the rat:

(i) Morphology and classification
(ii) Case studies of laboratory behaviour?
(iii) The rat throughout history; plagues
(iv) Various types of rat; characteristics of each; modes of distribution, by migration, by ship, by drifting ("sweepstakes" migration).

7 Reporting

At the conclusion of the term, each group of students should have compiled a report to be presented to the class.
This would consist of -

(a) written report
(b) verbal and visual demonstration
(c) discussion

Processes and abilities that could be developed:

1 Observation and recording by -
  (a) tabulation
  (b) written
  (c) drawing

2 Measurement of length, mass, volume - use of ruler and lever balance

3 Graphing of results

4 Manipulative skills in handling animals

5 Compiling a written report

6 Presenting this report to a large group

7 Discussion

Special equipment required.

1 It will be necessary to investigate the sources of supply of suitable annimals throughout Australia.

(a) Contact Health Department Officers to discuss regulations about the keeping of rats, mice, rabbits et al.

(b) Contact Biological Supply Houses to see whether they will stock them for us; quotes on costs and supply times.

(c) Some contacts in Victoria
(i) Melbourne University Zoology
(ii) Commonwealth Serum Laboratories
(iii) Pet shops

(d) Contact Dr Kenneth Brennan,
Chairman,
Rat Advisory Committee,
Melbourne City Council
see the cutting from the Age of April 29th 1970.

2 Cages - Investigate the possibilities here
(a) Obtain some cages from Selbys
(b) Obtain a Malvern Environmental Chamber - see Griffin and George Catalogue, page 902
(c) Study Education Department equipment lists for all States, to find out what cages are on supply

3 Feeders for water and food.

4 Thermometers

5 Food-Investigate what they will eat, how much, and what it costs

6 Mazes

7 Exercise wheels with revolution counter

8 Nesting boxes

9 Rulers and tail measuring box

10 Lever balance, with weighing cage

Suggested References for MDO

Mrs. Atkins, "Genetic Experiments with Mice" in Australian Science Teachers Journal. 12,3, November 1967, 102-104

Perhaps Mrs. Atkins could be a useful advisor. She was at St.Columba's College, Essendon, in 1967.

Baldock, R.N. et al, Discovery in Science, Practical Book 1, Adelaide, Eyers, Eberhard, Chittleborough and Morley Ltd, 1968, 162-168.

Baldock, R.N. et al, Discovery in Science, Practical Book 2, 125-127

Barnett, S.A. "The Rat's World" in Discovery, July 1957, 293-298

Keeling, C.H. Mice and Rats as Pets, Royles Handbooks.

....5/-

Roberts, M. F. Guinea Pigs, Jersey City, N.J., TFH Publications.

Roberts, M. F. Mice as Pets . Jersey City, N.J. TFH Publications.

School Science Review, 160, June 1965, 646-658

Snell, G.D.(ed), The Biology of the Laboratory Mouse, N.Y. Dover, 1956.

Zinsser, H. Rats, Lice and History, London, Routledge, 1943
(Swinburne 616 992 ZINR)

Skinner, B.F. "How to Teach Animals", in Sci.Am., Dec. 1951

Suggested Format

1 Movie film as introduction

2 Film loop on the handling of rats

3 General reference books on rats and other mammals

4 A general laboratory manual on caring for organisms

5 Booklet with suggestions for investigations - about 32pp.

4 Second Specification:
(This is produced by the Materials Development Officer who will develop the unit, in consultation with a discussant, usually an Area Specialist. The MDO is encouraged to use initiative and depart from the first specification where it is considered to be desirable).

Title: Mice and Men Stage 1
Length: approx. 20 40-minute periods

Number 102

1 Ideas Relevant to the Environment Scheme

1.1 The brosphere contains a large number of different species.

1.2 We should have an understanding of several species and their requirements.

1.3 This is essential to an understanding of the functioning of the biosphere and therefore to the way that humans affect it.

2 Main Science Ideas

2.1 Human characteristics such as growth, feeding, reproduction, breathing excretion and behavior can be studied by analogy, using small mammals. These can be manipulated and experimented with, whereas humans can not. Also they exhibit changes such as growth far more rapidly and so are more convenient to study.

2.2 The similarities of humans and mice can be studied to provide evidence suggestive of a common ancestry and the definite features of the Class Mammalia.

2.3 The difference between humans and mice can be studied to indicate divergence and adaptation.

.....6/-

2.4 There are definite requirements for organisms of which the mouse is an example:

2.41 space - territorial behavior, exercise
2.42 temperature - nest construction
2.43 food and water
2.44 removal of waste products

2.5 Organisms exhibit characteristic patterns of behavior, both instinctive and learned:

2.51 food seeking behavior by infants and by adults
2.52 avoidance of danger by retreat
2.53 aggression - defence of territory or mates
2.54 nesting behavior and care of young
2.55 mating behavior

2.6 The growth of an organism follows a sigmoidal pattern which can be classified into infancy, youth, maturity and senility. Weight and tail length of mice can be measured regularly.

3 Useful Background Knowledge

3.1 Concepts of weight and volume

3.2 Ability to add, subtract and divide

4 Intended Outcomes

4.1 Knowledge Outcomes
4.11 Similarities and differences exist between man and mice

4.12 Different species of mice and other animals exist and therefore there is a need for classification. Terms - class, order, family, genus and species are introduced.

4.13 Mammals can be divided into three groups:

egg laying mammals	(monotromes)
pouched mammals	(marsupials)
mammals with a placenta	(placentals)

4.14 Mice and other animals are used in medical research

4.15 Mice, as well as man or other animals have definite requirements and exhibit characteristic patterns of behavior.

4.2 Ability outcomes
To be able to:

4.21 look after an animal

4.22 observe accurately

4.23 measure weight, volume and length

4.24 record results by means of graphs, tables, diagrams and written description

4.25 complete a written report

4.26 present the report to the class

4.27 discuss the report

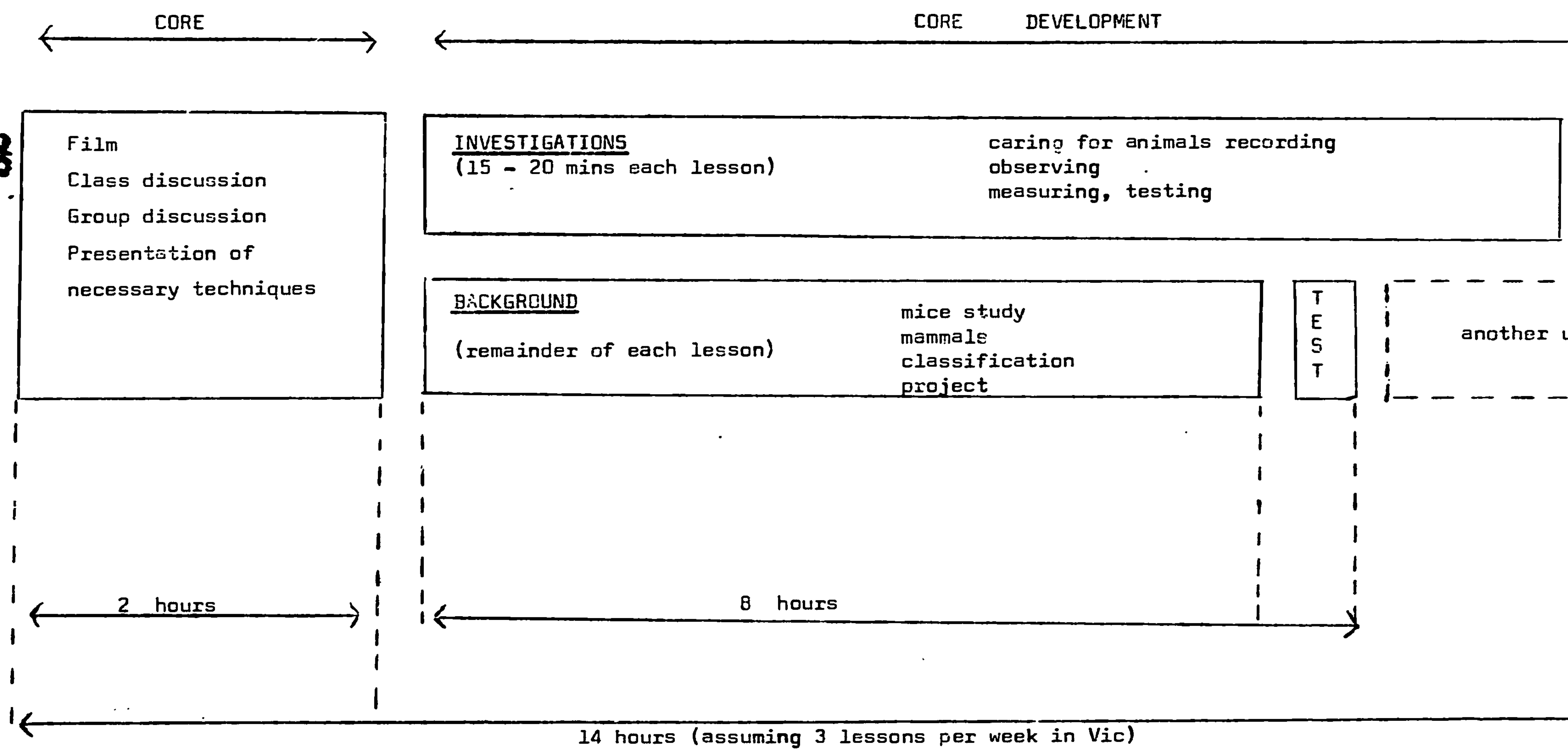
4.3 Affective outcomes

4.31 to accept responsibility for regular care of the animals

4.32 to develop an attitude of care for organisms rather than cruelty

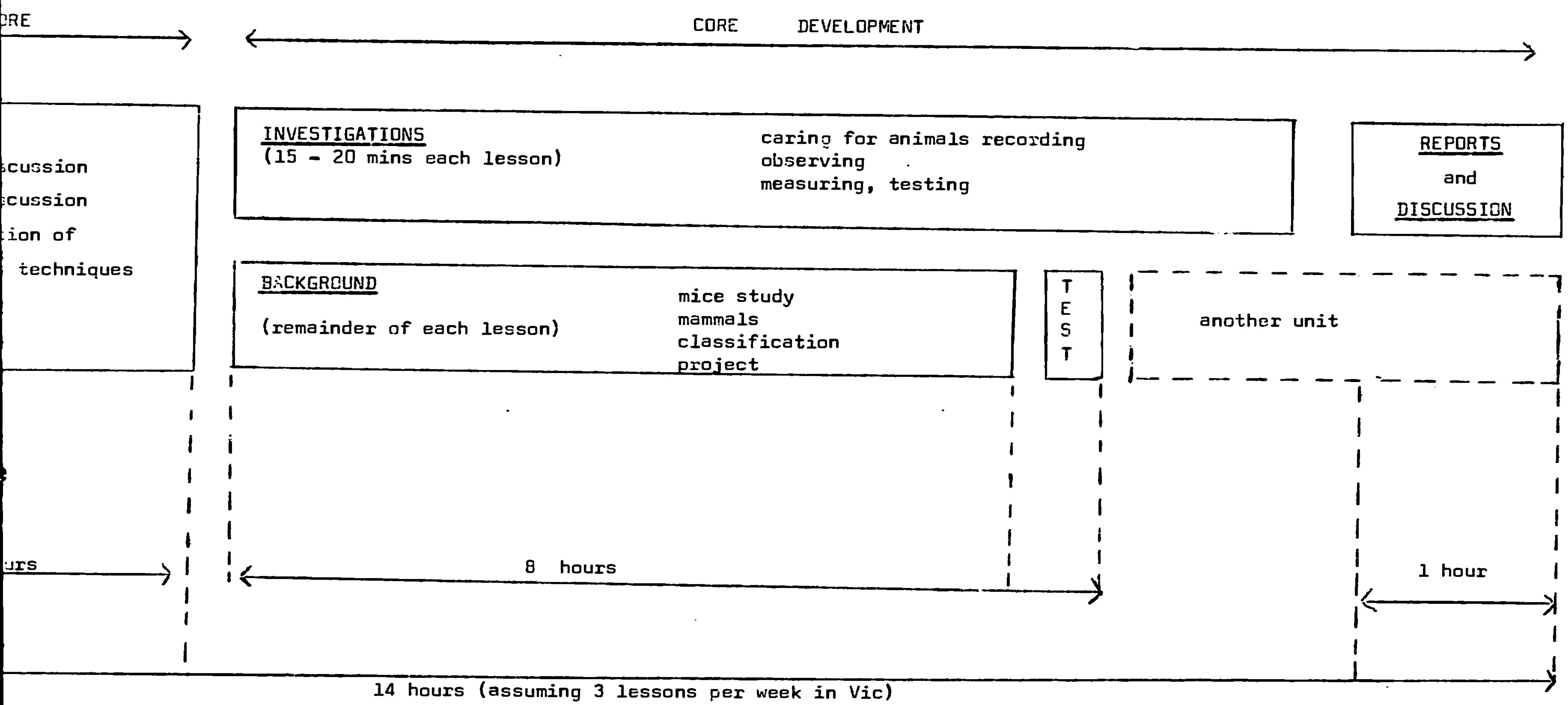
4.33 to become more confident in observing, measuring, reporting, discussing and handling animals.

5. FLOW CHART OF STUDENT ACTIVITIES



Length in hours of Investigations would vary from State to State, depending on the number of lessons per week.
The Investigations must extend over a period of about 6 weeks. In N.S.W., with 5 lessons per week, Investigations woul

5. FLOW CHART OF STUDENT ACTIVITIES



ꞏn hours of Investigations would vary from State to State, depending on the number of lessons per week.
ꞏstigations must extend over a period of about 6 weeks. In N.S.W., with 5 lessons per week, Investigations would last 20 hours.

6. Content and Sequential Development of Core Materials

6.1 16mm film about 10-15 minutes long, illustrating some of the behaviours, requirements, growth and feeding of a range of small mammals.

Alternative treatment: A booklet containing photographs and diagrams of aspects of behaviour and growth. This could be supplemented by wall photographs.

6.2 Class discussion
After seeing the film or looking at the book a large number of questions can be asked and possibilities for investigations will arise.

6.3 Group discussion
Groups discuss possibilities for investigations and then each group will choose several experiments contained in the unit. The teacher will have to advise each group and he may decide that all groups are to a particular experiment.

6.4 Presentation of necessary techniques

6.41 A cassette film showing techniques of handling animals. (David Bruce of ACER has agreed to demonstrate these techniques to put on an 8 mm film loop.)

6.42 There should be general reference books available on the care and handling of laboratory organisms. All students would have to read this book and perhaps answer some questions in their notebooks.

6.43 Instructions and suggestions
For sexing mice
For keeping records of body weight and tail length of mice
For keeping records of food and water consumed
For Behaviour investigations -
observation of movement, rest, feeding
response to stimuli
skinner box learning to push bar to release food
maze running
exercise wheel counting
Techniques of drawing to scale, close study of morphology.

Graphing and measurement techniques for volume, weight and length of rats and food and water consumed.

This concludes the core. The observations and background work have been placed into the core development because students have a choice in the experiments as well as the background work.

7. Core Development

7.1 In each lesson, a definite time should be allocated to care for the mammals and make observations. This may take from 15 to 20 minutes at the start and reduce later on. During the remainder of time in each period background work will be done.

7.2 Students will make their observations in groups. Two to three students per group would be ideal. Each group will receive a set of mice. A 'set' should include:

one adult male
one adult female
one juvenile male
one juvenile female

Therefore two distinct sections of the life cycle can be observed simultaneously, that is, growth in the juveniles and reproduction in the young.

It is essential that the ages of the bought animals are known.

8. List of Possible Investigations

8.01 Parts of the animal
Observation of mouse under a beaker (one mouse per student or per group)

Identification of different parts which are clearly visible.

'Actual size' diagram of the mouse drawn in students' notebooks and labelled. Instead of a diagram, the mouse could be photographed. Photos could be stuck into notebooks and labelled.

8.02 Activities of the mouse
(as in JSSP Red Series - Volume 7)

8.03 Do mice respond to certain foods?
Recorded in table form in student's notebooks.

8.04 Growth of mice
Weighing mice and measuring tail length at intervals.
Record in table form
Drawing growth curves.
From this experiment students can find out if mice grow faster when they are young, if they stop growing after a certain period, if males and females grow at the same rate, etc.

8.05 Pregnant mice and body weight
Weighing mouse at intervals before and after birth of litter.
Calculating approximate weight of litter.
Record in table form
Each doe should have a record card attached to the cage on which details of birth of litter can be recorded.

8.06 Temperature of the nest and cage.
Teacher may be able to measure temperature of a mouse and of students.

8.07 Changes in form of animals
Measuring tail length and body length of a young mouse at intervals.
Record in table form - calculating % of length that is tail
Graph of tail length/body length
Drawing two diagrams of mouse at different intervals to show change in proportion (actual size in cm).

8.08 Food consumed
How much food and water does the set of animals consume in one week?

8.09 Growth and exercise
Using a mouse with exercise wheel and one mouse without (control experiment). Measuring weights of excercising and lazy mouse at intervals. Record in table form and graph.

8.10 Does temperature affect growth?)
)   control
8.11 Does the amount of food given affect growth?)   experiments.
)
8.12 Does the amount of light affect growth?)

or

8.13 Do mice prefer light or dark?
A cage is set up where the mouse has a choice.

8.14 Is the amount of activity affected by temperature?
One mouse uses exercise wheel in cool and another in warm conditions.

8.15 Mazes
How many trials are needed until mouse finds exit? Use different mice. Students could let time elapse between trials, to find out if the mouse can remember.

8.16 Skinner box
How many trials are needed until mouse pushes button to get food? Does each mouse take the same time to learn the trick? Let time

elapse between trails to find out if mouse remembers.

8.17 Colour discrimination
Conditioning mice to press a button of a particular colour of two or three in Skinner box.

8.18 Shape discrimination
Conditioning mice to push a button of a particular shape out of two or three different shapes.

8.19 Behaviour
How do mice respond to a female or a male intruder?

9. Mice and Man

Each investigation can be related to man by asking the student a particular question once he has completed the investigation. Possible questions could be:

9.1 Are there external similarities and differences between mice and humans?

9.2 Which activities do you have in common with mice?

9.3 Do you show preference for certain food? Name 10 foods you like and ten you do not like.

9.4 How does growth of mice compare with human growth?

9.5 Why is the temperature in your bed different from the temperature in your bedroom?

9.6 How much food do you eat in a day? How much does your father eat? Why is there a difference? etc.

10. Records of Investigations

In table form on prepared worksheets or instructions are given and students rule up tables in notebooks. The worksheets could have space for drawing graphs and writing conclusions or answering questions which are asked at the end of most investigations. Some investigations require drawings of mice.

11. Reports

At the conclusion of the investigations, each group of students should have compiled a report to be presented to the class. This would consist of:

11.1 a written report

11.2 a verbal and visual demonstration

11.3 a discussion

Reports will vary from group to group, as they would have done a combination of different experiments.

12. Background Activities

12.1. Mice and man are mammals. A mammal has hair or fur and suckles its young.

12.2 Different types of mammals - egg laying (monotremes)
- pouched (marsupials)
- placentals

Photos, diagrams or a film loop could illustrate points relevant, that is, a monotreme laying eggs, suckling its young; birth of a kangaroo, journey to the pouch, attachment to nipple; a model of a human embryo in the placenta and birth of one or two placental mammals.

Class discussion on film. Simple explanation given why monotremes and marsupials exist only in Australia

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Class discussion on film. Simple explanation given why monotremes and marsupials exist only in Australia

Recording of information in table form on prepared worksheets or in notebooks.

Types of placental mammals. Mr. X decided to put them into the following groups since there are such a variety of these mammals:
swimming, flying, insect eating, toothless, flesh-eating, hoofed, gnawing,

with hands.
Exercise in table form containing a list of 20-30 mammals and the different kinds. Students tick respective squares.

Photographs of the listed animals should be available and an animal encyclopaedia.

12.3 Study of mice in the form of a number of assignments which students can choose from. Students can do the assignments by themselves or in pairs at their own rate. ASEP will produce a booklet cntaining information on mice as well as handling of laboratory organisms. The study of mice will deal with:

12.31 different kinds of mice (wild, commensal, marsupial, placental)

12.32 behaviour of wild mice

12.33 history of mice plagues, control, modes of distribution

12.34 case studies of laboratory behaviour

12.35 importance of mice in medical research

12.4 This information could be presented in the form of:

12.41 comprehension exercises with photos or diagrams

12.42 comic strip diagrams (e.g. of plagues, introducing mice into Australia)

12.43 colour photographs of different kinds of mice

12.44 copies of newspaper articles on recent mouse plague in S.A.

12.45 excerpts of original reports from journals. This shows the students how scientists record their work. A simpler version of the excerpt is to be given underneath so all students can understand it.

Class discussion takes place when all students have completed their chosen number of assignments.

12.5 Need for classification
There are about 55 different kinds of mice in Australia. $1\frac{1}{4}$ million different kinds or species of animals exist on earth. Necessity for grouping animals.

12.51 Introducing exercise. Students use a worksheet similar to a sheet of stamps, containing diagrams of about 20 particular objects (scissors, plates, brushes etc.)

They are asked to put these objects into, say, four different groups. For this, each student has to decide on a method of classification (colour, shape, use, material etc.)
Students can tear objects off sheet, group them and paste them onto a prepared worksheet in groups, giving method of classification and reason why objects were grouped in a particular way e.g.
Group 1 fork-spoon-knife-plate used for eating
Results can be compared. Methods of classification may vary.

12.52 A similar worksheet can be produced for a variety of animals which students group and give method of classification as above. Students will find they group the animals according to their appearance or the way they live.

12.53 A third worksheet could ask students to tick squares on a table giving names of animals and characteristics of hair, feathers, scales, wings, legs, fins, lay eggs, suckle young etc.
They could then be asked to put these animals into groups and give reasons.

12.54 Classifying mice

Students can classify house mice themselves by having a prepared key as in Unit 2 What are living things made of? Activities in science p 15

A family-tree type diagram can be produced to show classification into species - genus - family - order - class. Photographs of the animals could be used.

12.6 PROJECT

Written work on a particular mammal.
Students choose a mammal from reference books available and work singly or in pairs at their own rate.

Description with illustrations could be done under the following headings :

economic value	appearance
conservation	feeding
special characteristics	behaviour
(e.g. speed, camouflage, size, intelligence.)	distribution
	life cycle

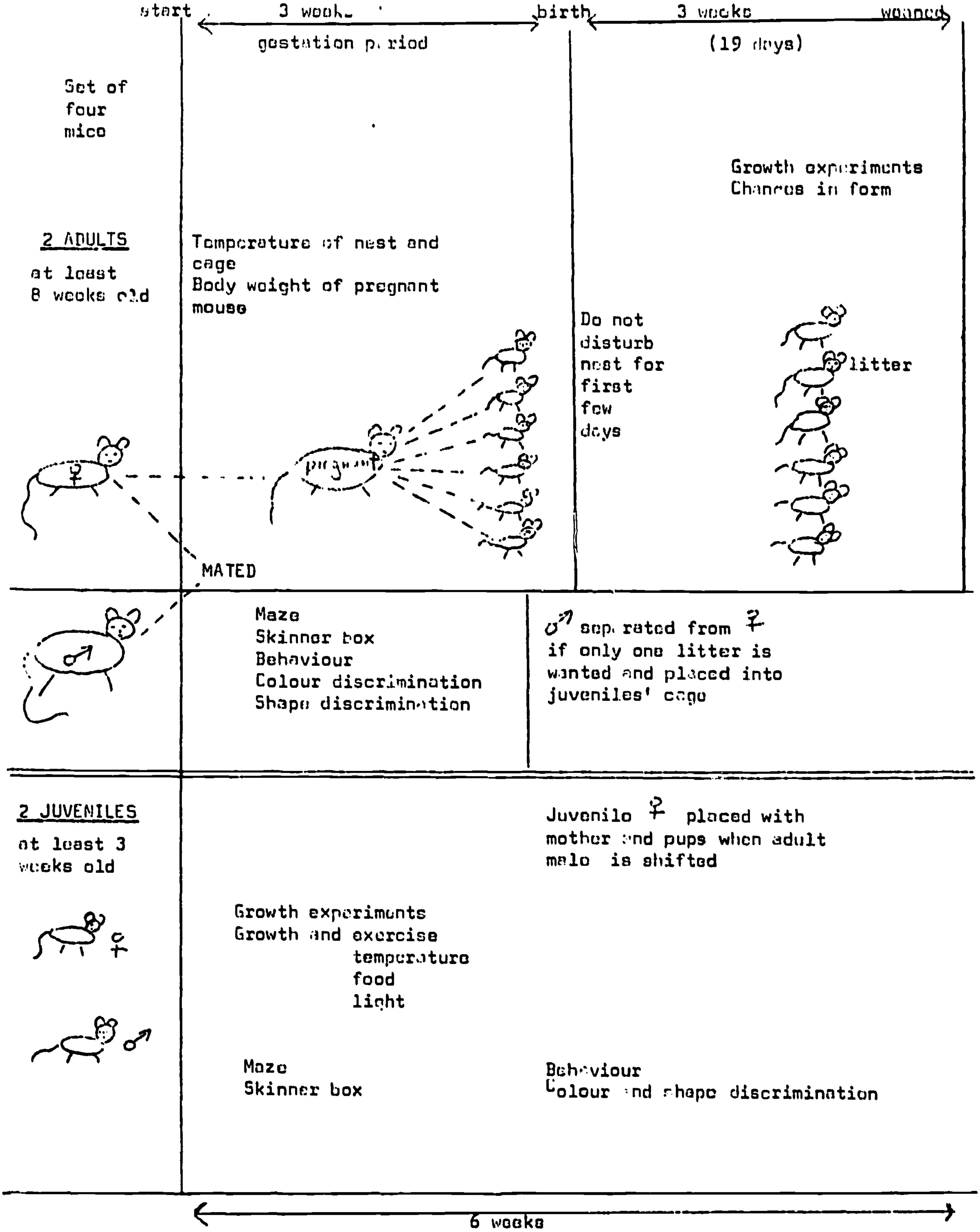
12.1 and
12.2 have to be done before 12.3, 12.5 and 12.6 and which can be done in any order i.e. some students carry on with the project, while some do classification and others do assignments on mice.

13. Testing

Amount of testing is limited since there is a choice within observations mouse study and the project.

An objective test could be given on mice in general, types, characteristics and classification of mammals.

14. Flow Chart of Mice activities



All 4 mice could be used for:

a) parts of a mouse
b) activities of a mouse
c) food consumed (pellets + water)

Cages: Two cages, one for adults and one for juveniles. After approximately 3 weeks, adult male is placed into juvenile cage and the juvenile female is placed into adult cage.

15. Facilities Required

A laboratory is essential. In a classroom there would not be enough room for balances and cages etc.

Equipment listed is for a class of 40 students divided into groups of four.

Items	Number per Group	Number per class
Mice	4	40
Cages containing food and water feeders	2	20
Food in pellet form (42 days x 4 mice x 5g)	1 kg	10 kg
Sawdust or kitty litter	2 cm per week	
Balances	1 between 2 groups	5
mouse tail measuring box	1 between 2 groups	5
rulers (30 cm)	1	10
record cards	4	40
thermometers $(0-50^{0}c)$	1	10
Skinner Box		1 or 2
exercise wheel with revolution counter	1 between 2 groups	5
environmental chamber		1 or 2
trolley for storing cages		1
beakers (250 ml)	1	10
black cardboard	1 sheet	10 sheets
maze, T or Y shaped		2 or 3

16 BIBLIOGRAPHY

16.1 Books suitable for school libraries

Australian Academy of Science, Biological Science: The Web of Life
Canberra, ACT. 1968
Student's Manual Part I, Exercise 4. Idea of classification with exercises

Basil-Marlow. Marsupials of Australia, Jacaranda Pocket Guides
Description, distribution, biology of all marsupials.

Cansdale, George. Pets Book , Phoenix House Ltd., London, 1959
Information on pets in general, including mice and rats

Department of Public Health, Food Handling, S.A. 1969
p. 12-13. Pests and their control

Hamilton-Wilkes, Monty. How to look after pets
Angus and Robertson, 1966

Life Nature Library. The Mammals
The Primates
Animal Behaviour (case studies of rats p 24-25, 140-142 and of new-born monkeys p 28-29)

Nuffield Biology, Text II, Life and Living Processes.
p 142-152, Descriptions of bedding and litter, food, cages, handling, breeding and sexing mice, growth experiments and making growth curves.

Sharland, Michael Tasmanian Wild Life, Melbourne University Press

Shaw, M; Fisher, J. Animals as Friends, J.M.Dent & Sons, London '63
General Pet Book

Troughton Ellis, Furred Animals of Australia, Angus and Robertson 1962
Conservation, economic value, distribution and descriptions of mammals (mice p 295-304)

Wotherspoon, John. The Australian Pet Book, Lansdowne Press, Melbourne 1962

16.2 Books suitable for background knowledge

Atkins, Mrs. St. Columba's College, Essendon. Genetic experiments with mice, Australian Science Teachers' Journal, Vol. 13, No.3, November 1967, p 102-104
Article gives information on housing, feeding, watering, sexual maturity and mating, sexing and weaning of pups and killing of mice.

Barnett, S.A. The Rat's World, Discovery, Vol. 18, July 1957, p 293-298
Article on feeding behaviour, rat populations, males in conflict, influence of females, fighting and death, amiable behaviour.

Bibby, Cyril, Simple Experiments in Biology, William Heinemann Ltd. 1958
p 136. Experiment on change in body form of mouse, graph of t...

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Bibby, Cyril, Simple Experiments in Biology, William Heinemann Ltd. 1958
p 136. Experiment on change in body form of mouse, graph of tail length/body length.

BSCS Pamphlet 16 Growth and Age p 7 shows diagram of human growth. This could be used to compare with mice.

BSCS Innovations in equipment and techniques for the biology teaching laboratory.
p 25 How to keep small mammals in a gallon jar.
p 30 How to make a food hopper and a watering device.

Davis, R.A. Rats and Mice, Discovery, Vol.17, March 1956 p 115
Number of known species of mice and rats, history, differences between wild and commensal mice.

Nuffield Biology, Teachers' Guide II, p 95-104
1. Type of mice needed for experiment.
2. How to keep mice for growth experiments
3. How to make a cardboard funnel for transferring mice from cage to balance
4. How to make a mouse tail measuring box
5. How to make record cards.

Skinner, B.F. How to teach animals, Scientific American, Vol. 185, No.6, December 1951, p 26-29
Article describes simple techniques on training a dog and a pigeon by rewarding the animal and using a signal which the animal associates with food.

Mein, G.A. Milking mice to advance human cancer research, Journal, Department of Agriculture, Victoria, Vol.66, No.11, November 1968, p 416-17

Tretherwio, E.R. Effect of combustion temperature on epithelial damage by tobacco smoke, Scientific Australian, June, 1968, p 9-16 A.
Possibility for case history or excerpt.

Rats andmice on cereal farms, Queensland Agricultural Journal, Volume 95, 1969, p 403
Control measures - hygiene around buildings, exclusion from buildings, poison baiting, insecticides, fumigation.

Wallace, Dr. Margaret E., Department of Genetics, University of Cambridge,
Using mice for teaching genetics I, The School Science Review, Vol. 46 June 1965, No. 160, p. 646-658
Descriptions on how to breed mice, photographs of the Cambridge mouse cage and colour photographs of eight varieties of mice.

17 List of Materials to be Produced by ASEP

17.1 Book
- introduction to mammals
- presentation of techniques
- details of possible investigations
- information for background activities
- sources of animalsand equipment
- bibliography

17.2 Worksheets

17.21 Care and handling of mammals (self-test)

17.22 Graphing and measurement techniques

17.23 Parts of the animal (8.01)

17.24 Activities of the mouse (8.02)

17.25 Growth of mice (8.04)

17.3 Film loop on handling mammals (David Bruce)

18 Supplementary Materials

18.1 16mm film on introduction to mammals

18.2 General reference books on care and handling of laboratory organisms

18.3 Information books for background activities

18.4 Films or film loops commercially available.

Document 13A

35A
SER/GR/VK
16 October 1970

Australian Science Education Project

PREAMBLE TO THE AIMS

1 The accompanying document contains a statement of aims for the Project. They are expressed in terms of the effects which it is hoped will be produced in children who learn science using our materials.

2 The production of the statement of aims has proved to be a fluid process. Starting from the first public statement of aims, made by our Director Mr H.O. Howard at the Guidelines Conference in January 1970, a pattern of changes may be traced. A proposed set of aims, which expanded this first statement, was formulated by Conference participants. In turn, this set of aims was modified several times (one form appeared in Newsletter No.1) and evolved eventually into its present form.

3 Some criteria that were kept in mind when stating the aims included:

3.1 The aims should be simple, and contain as few points as possible, so that developers and teachers may recall them easily.

3.2 The aims should be open to check to see if they are being achieved when the materials are used in schools.

3.3 The aims should be general statements for the whole ASEP program on which more specific objectives for individual units may be based.

3.4 The aims should widen the horizons of teachers, rather than restrict what they do.

4 The Project would appreciate comments on whether the aims form suitable guidelines for the development of materials for teaching science to junior secondary school students, as well as any other comments.

Document 13

35
SER/GR/VK
16 October 1970

THE AIMS OF THE AUSTRALIAN SCIENCE EDUCATION PROJECT

1 The broad aim of the Project is to design science experiences which contribute to the devolopment of children. More specifically, the science experiences are aimed at developing:

1.1 some understanding of man, his physical and biological environment, and his inter-personal relationships

1.2 skills and attitudes important for scientific investigation

1.3 some understanding of the nature, scope, and limitations of science

1.4 some understanding of, and concern for, the consequences of science and technology.

2 Two statements are to be considered in conjunction with these aims:

2.1 The kind of understanding at which this Project aims enables children to operate more effectively in their environment.

2.2 To arouse and foster the interest of children is of prime importance in the development of understanding, skills, and attitudes.

A brief expansion of these aims and statements follows. It is not intended to be prescriptive, nor to set detailed limits to their interpretation.

The broad aim of the Project is to design science experiences which contribute to the development of children.

3 Science is justified in the junior secondary curriculum because science experiences contribute in unique ways to the personal and social development of children. The Project will seek those experiences which best contribute to this growth and are relevant to the stage of development of the children. It is less concerned with the training of future scientists and technicians

To develop some understanding of man, his physical and biological environment, and his inter-personal relationships.

4 A program of science experiences based on ASEP materials and philosophy will, it is hoped, give all students some understanding of themselves as individual organisms, the environment in which they live, and their inter-relations with other individuals and groups. It is believed that for most junior secondary students the more abstract scientific concepts are less pertinent to their lives than are some of the more practical aspects of science. Knowledge considered to be most relevant to children will be favoured.

.........2

To develop skills and attitudes important for scientific investigation

5 The Project aims at encouraging inquiry and developing skills and attitudes that will enable the individual to inquire efficiently and to solve relevant problems.

Such skills include those of

5.1 observing and ordering observations

5.2 detecting patterns and relationships

5.3 formulating problems

5.4 obtaining information relevant to a problem e.g., through library search and experimentation

5.5 interpreting findings critically.

6 It is also recognized that skills associated with effective communication are essential in science and deserve attention in a science course.

7 Some of the attitudes important in science are also important for the personal and social development of the individual. These include attitudes which predispose an individual to

7.1 demand evidence in support of claims

7.2 postpone judgment when available evidence is inconclusive

7.3 change opinions in the light of incompatible data

7.4 have confidence in tackling new problems

7.5 seek rational explanations

7.6 prefer quantification

7.7 be receptive to change and flexible when required

7.8 be persistent

7.9 support the extension of knowledge

7.10 be co-operative

7.11 be critically tolerant of the opinions of others

7.12 represent observations honestly

7.13 admit to error

7.14 take responsibility for actions and their consequences.

To develop some understanding of the nature, scope and limitations of science

8 An important principle in science is that of proposing an hypothesis or constructing a model, testing it, and in the light of the result, modifying or rejecting it if necessary. No test can prove an hypothesis or model true; it can only provide corroborating evidence.

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9 A variety of factors may give rise to the generation of new hypotheses or models; these include intuition, trial and error, coincidence and accident.

10 Science is a dynamic, developing discipline. The laws, theories, conceptual schemes etc., of science are not unquestionable statements of truth, but change as scientific understanding changes.

11 Science advances through the use of the processes of inquiry, and an important aspect is communication among scientists. Conventions which aid communication are standardized by international agreement.

12 Science advances as a result of the efforts of scientists with varied allegiances and personalities.

13 A great diversity of topics can be investigated by scientists, but not all subjects are accessible to scientific investigation. It is important to help children understand which problems are open to scientific investigation, and which are not.

<u>To develop some understanding of, and concern for, the consequences of science and technology</u>

14 The findings of science have led to many technological advances which have contributed enormously to human welfare and the process of civilization. The energy requirements and the quantity of raw materials necessary for a technological culture are immense, as are the wastes.

15 The consequences and ramifications of scientific and technological innovations must be investigated in terms of the effect upon both the aesthetic and ecological aspects of the general environment. A compromise may have to be reached between the increase and proliferation of the products of technology and the maintenance of the environment. The problem of recycling of materials deserves greater attention.

16 Advances in medical and biological science have improved the health and viability of individuals, but have also removed many of the factors that controlled the size of human population. The increasing population, and the increasing proportion of the population moving into a more highly technological culture magnify environmental problems.

17 Science has a responsibility to inform people of the problems associated with technological advance and the possible consequences to the environment, even though the creation and solution of such problems are often political and economic rather than scientific.

18 Children can develop some of these understandings and concerns from an exploration of their own immediate environment.

<u>The kind of understanding at which this Project aims will enable children to operate more effectively in their environment</u>

19 The kind of understanding at which this Project aims will arise from students engaging in scientific activities. They will observe, describe, classify, formulate and test hypotheses when studying those natural and social phenomena that are readily available, and relevant to their stage of development.

20 When making judgments regarding the growth in understanding of students, the criteria used should rely on what the children can do in a given environment, rather than what they know about it.

21 The Project believes that the production of original ideas, a process not subject to known rules nor bound by set procedures, is likely to be fostered by learning experiences which are designed to have children operating scientifically, and in which solutions to some of the problems are not predictable. It is hoped to provide the kind of conditions in which creative thinking in children flourishes since progress in science, as in many other fields, is dependent on the inspirations of individuals.

<u>To arouse and foster the interest of children is of prime importance in the development of understanding, skills, and attitudes</u>

22 To operate scientifically and to gain understanding of the environment are potentially interesting to children. These interests must be fostered. It should be remembered that not all children will be interested in the same things, nor will they be interested in gaining the same set of skills and attitudes.

Document 14

DEV/LD/KR
6 October 1970

Australian Science Education Project

THE MAIN IDEAS TO BE DEVELOPED IN ASEP MATERIALS

1 The main ideas developed in the ASEP materials will be influenced by many factors. Some of these are

1.1 the experience and judgment of development staff

1.2 knowledge of the abilities of teachers and their needs

1.3 knowledge of available facilities

1.4 knowledge of the abilities of the children concerned.

Such factors will generally be used as bases for exclusion of certain ideas or for choices among alternatives. In this paper only bases for inclusion of ideas are dealt with.

2 Five sources of ideas were examined.

2.1 The child's environment and his understanding of it.

2.2 The content of science i.e. present scientific knowledge.

2.3 The nature of science, as revealed by its history.

2.4 Procedures used to extend knowledge, including processes of scientific investigation and communication.

2.5 Attitudes related to science and scientific investigation.

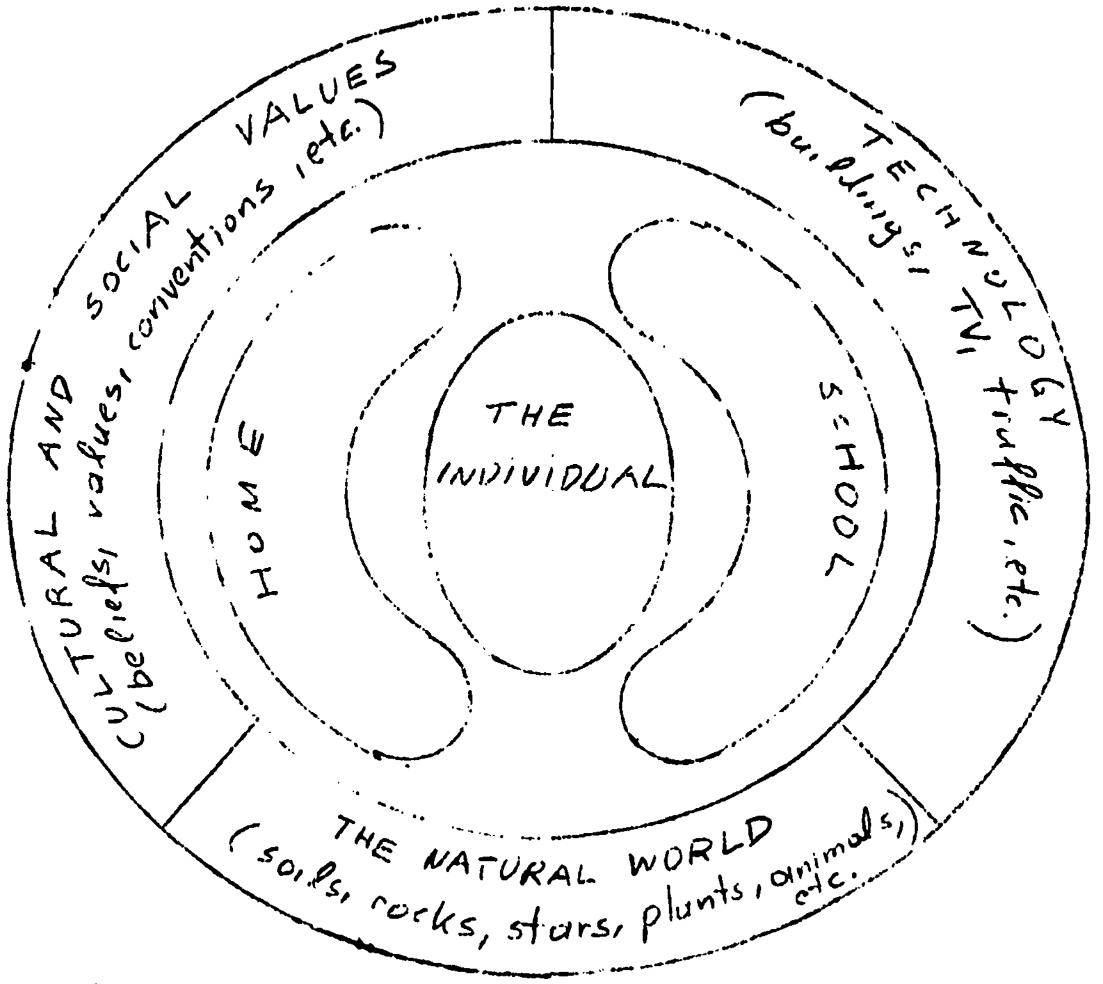
2.6 Three stages of intellectual development, from Piaget's concrete stage through an intermediate transition stage to the formal stage.

3 The main sources of ideas for inclusion in ASEP materials arise from consideration of the environment of the child, the nature of science and the present state of scientific knowledge. While some ideas may be included to promote certain attitudes or to develop certain procedures for extending knowledge or to be relevant to a particular stage of development, it is believed that these sources of ideas will be of minor importance.

THE ENVIRONMENT OF THE CHILD

4 The child's 'environment' includes all the objects, forces and conditions, both internal and external, that affect the individual.

5 The following diagram gives some indication of the ranges of sources of stimuli to which children respond.



6 Certain qualifications to the diagram are necessary.

6.1 The various components of the environment are both overlapping and interdependent.

6.2 The individual is influenced by his 'internal environment'.

6.3 The school and home components determine largely what environmental stimuli the child receives

7 As a basis for inclusion of topics related to the child's environment a list of important ideas was organized into a scheme which is referred to here as 'the environmental scheme'.

8 In the form stated here, the environmental scheme is expressed as adult ideas. It is intended that the ideas will be presented to children in such a way that they will be seen by the children as relevant to their present life and useful in helping them to gain an understanding of their environment.

9 Emphasis will 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.

THE ENVIRONMENTAL SCHEME - AN OUTLINE OF THE MAIN IDEAS INVOLVED

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

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11 Man must realize the far reaching effects of his continued non-cyclic modification of his environment, both in terms of the consequences of changes made to the environment and in terms of effects of the changed environment on man and other living organisms.

<u>In what ways does man, the individual, resemble and differ from other individual organisms?</u>

12 An essential part of understanding of the environment and its interaction with man is an understanding of how man functions as an individual, compared with how other living things function.

13 Man has certain life requirements for food, shelter and protection which are similar in many respects to those of all other life but which differ in other ways. Part of the difference is due to man's ability to control his environment.

14 Man's body consists of systems which function together as an integrated unit. These systems are similar in many respects to systems in other individual organisms. There is great diversity among organisms with respect to body structure and functions.

15 The systems are concerned with

15.1 intake and absorption of food materials

15.2 utilization of absorbed food for body growth and repair, and for energy

15.3 disposal of excess materials

15.4 maintenance of the internal environment including defence against disease

15.5 communication among body parts

15.6 growth to maturity and reproduction of new organisms

15.7 reception of stimuli from the external environment

15.8 movement and behaviour relative to the external environment.

<u>How do interactions among groups affect decisions made by man?</u>

16 Most of man's efforts to change the environment and the system of values upon which his behaviour is based, arise from group interactions rather than the needs of individuals.

17 Individuals with common interests form structured groups which establish their own goals and adopt procedures to achieve those goals.

18 Group structures differ according to patterns of work, power, communication and personal relationships. Each individual has a role to play with respect to each pattern of structure.

19 Pressures within groups affect individuals, group structure and group goals. Pressures among groups affect groups and society. In a rapidly changing society, flexibility in adopting new roles is important for individual survival.

20 Understanding of man's behaviour as a member of a social group has been gained partly through the study of group behaviour in other organisms.

In what ways has man extended his ability to explore and manipulate his environment?

21 The ability of man to learn about his environment and to make use of it has been increased by man-made devices and procedures which extend his sensory perception and mental abilities and his ability to use his own energy to move and to manipulate.

22 The accuracy, sensitivity and range of man's sensory perception has been extended by development and use of instruments and communication devices.

23 Man's capacity to learn has been increased by the organization of existing knowledge and by procedures, such as the use of theories and models,for extending knowledge.

24 The precision and speed of mental processes has been increased by the development and use of devices for processing, storing and retrieving information.

25 Man's ability to move in his environment, to move things and to perform activities, by use of forces he can exert within his own ability and energy range, has been increased by the development and use of mechanical devices, tools and machines.

In what ways has technology changed man's environment?

26 Man's desire to make the world a better place in which to live, in terms of material comforts, financial and national security, has led to great technological advances. One consequence has been an exploitation of the natural environment to the extent that man's future in his natural environment has been jeopardized. An understanding of this situation involves a knowledge of how technology has affected man and the natural environment.

27 Technology has made increasing demands on the world's resources of raw materials. Man has rapidly increased his efforts to discover more deposits of these materials, extract them from their present localities and prepare them for use.

28 The search for raw materials has been accompanied by a search for synthetic substitutes and for new materials that will better serve the purpose desired.

29 Technological advance has depended on the development of better machines and the availability of energy at reasonable cost. This has led to a search for new energy supplies and the development of procedures for making energy more readily available. Devices to transform energy into usable form have been developed.

30 Technological society has required the rapid movement of energy, men and goods from place to place. Transport and transmission facilities have been developed to cope with this requirement.

31 Technology has led to improvement of man's material comforts-housing, appliances, working conditions, clothing, hygiene, leisure activities.

32 Man's health has benefited from improved food production due to better land management and usage, improved processing methods and better techniques for prevention, control and treatment of disease and body disorders.

33 One area of technology is concerned with space research which includes the establishment of artificial satellites. A significant portion of this area has developed from defence requirements.

34 Associated with technological advance there has been depletion of natural resources and addition of pollutants to the environment.

<u>What changes in the environment take place naturally? How has man interfered with these changes?</u>

35 The impact of man upon the natural environment can only be understood if the changes that take place naturally are known. Man should realize that he occupies only a small place in the universe but his effects on the earth and the life on it are far reaching.

36 Living organisms exist in ecosystems in which a balance exists among the various organisms present and their physical environment.

37 The materials and structures in the earth's crust are subject to continuous but slow change. Cycles of change are present and balances exist among crustal components and their environment.

38 The climate of the earth is affected by many factors including seasonal variations, latitude, ocean currents, topographical features, movements of air masses. Balances exist and cycles of change occur. There is a gradual change in climate due to certain changes in energy relationships.

39 The universe, of which earth is part, is an evolving body of matter and energy. Certain gradual, unidirectional changes are evident in stars and planets. Many changes occurring are cyclic.

40 Life on the earth is undergoing gradual but significant unidirectional evolutionary changes.

41 Man can use his understanding of his own functioning as an individual and as a group member, and the effect he and his technology have had on the natural environment to overcome present problems of pollution, over-population and depletion of natural resources. He can enjoy and make better use of natural resources and, at the same time, conserve them and the life dependent upon them.

<u>SCIENTIFIC KNOWLEDGE</u>

42 The following six themes have been chosen to assist in deciding which ideas from the total sum of scientific knowledge should be included.

43 The six themes are important ideas in science. Other ideas may, in general, be accommodated within their framework.

I <u>The matter of the universe can be organized into units</u>

44 The term 'unit' refers to any building blocks that can be organized into hierarchies. Thus at one time it may be appropriate to treat the cell as a unit of matter; at another, a single animal or part of the total population could constitute a unit.

II <u>Units can be organized into hierarchies</u>

45 Units can be classified into levels of organization such that a number of units of any one level are combined to form a single unit at the next higher level. For example, certain atoms are combined to form a single unit, a molecule, at the next higher level.

With few exceptions, a unit at any one level includes units from all lower levels as components and is itself a component of units at all higher levels.

46 A number of different hierarchies can be constructed, but all share the same lowest levels, for all matter consists of the same types of sub-microscopic units, namely, sub-atomic particles, atoms or ions, molecules. Above the sub-microscopic level, hierarchies differ according to the particular portion of the universe they describe.

47 There can be considerable diversity in structure and size among units at any one level of organization, for example, among molecules or among organisms.

III The behaviour of units can be described and predicted

48 An important outcome of adequate scientific description and analysis is a capacity to make predictions. The analysis requires the use of models, mathematical and statistical methods, intuition and logical reasoning.

49 Statistical methods enable prediction of the average behaviour of all units in a system. given the observed or deduced behaviour of a small but adequate sample. Statistical methods do not enable prediction of the behaviour or properties of individual units.

50 Description and prediction can proceed by the use of theoretical models. Although they cannot be proved, models such as the laws of thermodynamics and the theory of evolution are powerful in facilitating explanation and prediction as they have been found to be consistently valid.

IV Motion is an essential part of most phenomena

51 Many phenomena may be described in terms of changes in properties or behaviour. These changes may be described as being consequences of motion of units of matter. For example, the whole field of current electricity can be explained in terms of the motion of charged particles.

V Units interact within the dimensions of time and space

52 Interactions among and within units of matter may produce changes in form, properties or position. In the physical sense, this interaction can be described in terms of electro-magnetic, gravitational or nuclear forces (or fields), and can therefore be readily reduced to mathematical analysis. Units of living matter cannot be readily interpreted in like manner and it is more fruitful to study the behaviour of genetic material in terms of coded information and the energy transformation required to utilize this information in life processes.

53 The planets, natural satellites, stars, galaxies, and galactic systems are subject to transformations in substance, form, and position. These transformations involve exchanges of matter and energy and the systematic motion of celestial bodies in a gravitational field of universal dimensions. Movements of the earth and moon serve as convenient bases for time units.

54 Materials of the earth undergo transformations. The rocks are products of changes in the form and organization of the matter of which they are composed. In most instances, changes from one rock type to another also involve changes in volume, shape, and position of the material. The movement of molten rock material to the earth's surface and the transportation of sediment to the sea by rivers are familiar examples of changes in position. In contrast to the relatively slow geological changes, nuclear particles may undergo extremely rapid changes.

55 Several patterns of interaction are characteristic of living organisms:

55.1 Non-living matter becomes involved in processes and forms characteristic of living matter, but eventually returns to the non-living state. In a community, there is a cyclic transfer of matter between the various organisms and their physical environment.

55.2 The spatial distribution of individuals in a community results from interaction with the environment.

55.3 There are sequential patterns in the growth and fluctuation of populations.

55.4 There is an ecological succession of various communities in a newly formed habitat.

55.5 A great diversity of types of living organism has evolved over a very long period of time.

56 Other patterns of interaction in the natural world include:

56.1 The cyclic transfer of matter; for example, in the water cycle, convection cells, distribution of solar energy.

56.2 Stellar evolution sequences in the birth and death of stars.

56.3 Sequences of geological events, as revealed by patterns in rock strata.

56.4 Successive stages in the evolution of landscapes characteristic of particular climates, rock and soil types.

56.5 The sequential development of soil types.

VI <u>Interactions between units tend toward a state of equilibrium</u>

57 Man's experience has shown that two great principles apply without exception to every interaction. These two principles are embodied in the first and second laws of thermodynamics.

58 In the process of attaining equilibrium energy transformations and/or matter transformations occur. In most cases energy is conserved and matter is conserved. Where matter-energy transformations take place, the sum of energy plus matter is conserved. These conservations are embodied in the first law of thermodynamics.

59 The second law is concerned with changes in matter - the direction of these changes is such that greater randomness may occur in a system, but the reverse is not observed unless energy is supplied, i.e. complex molecules may disorganize into simpler components, but the reverse does not take place unless considerable free (or available) energy is available.

60 In living systems a relatively constant organization may be maintained, e.g., the charge on a cell membrane or the sugar level in the blood, but this requires the expenditure of energy with disorganization and death resulting if organism, or community, fails to utilize energy appropriately.

61 Homeostatic, or auto-regulating mechanisms, to ensure metabolic stability and energy balance are characteristic of living organisms.

62 The complex interactions of many different types of living organisms and their physical environment stabilize with the emergence of climax communities.

63 The input and output of energy from the earth as a planet is in balance, and results in patterns of atmospheric circulation.

64 All non-living systems tend towards either a minimum of potential energy or maximum randomness of molecular motion. The most disordered state has the greatest probability.

THE NATURE OF SCIENCE

65 In the following description of the nature of science it is not implied that the statements made apply to science as a unique study. The statements could be equally valid for other forms of human activity. It is appropriate to draw attention to certain aspects of science whether or not they are shared with other disciplines.

66 A study of the history of science is important as a means of gaining insight into the nature of science.

67 An awareness of the transformations engendered by science in man's thinking and beliefs in the past will help in developing an understanding of the impact of science and related technologies on past and contemporary society.

68 Science is a method of creating patterns out of the many things and happenings in the universe. The patterns are made by man and are his way of looking at nature. They represent the insight of the persons making them. Science is both the method of creating patterns and the patterns themselves.

69 One of the main methods of creating patterns is the use of experimental inquiry to look for constancy, to look for events or characteristics of events that repeat, always giving the same answer in the same circumstances. These constancies form a powerful tool for explanation and prediction, which can be verified by experiment.

70 The procedures of inquiry used by scientists follow no one clearly defined path. There are many procedures which can be followed in many different sequences but all of which lead to the extension of scientific knowledge.

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71 The patterns include generalizations, general scientific ideas that act as cores of thinking, i.e. the laws of science which can be regarded as generalized records of observed facts of nature, and finally, there is a small number of big ideas which act as integrative bonds transcending subject boundaries. Conventions are adopted by scientists and are part of the patterns created.

72 Scientific knowledge consists of the patterns created by man. The essence of scientific knowledge is found in its conceptual framework, which is made up of the major patterns described by scientists.

73 The patterns (laws, conceptual schemes, conventions etc.) are not unquestionable statements of the truth, but change as scientific understanding improves or changes. There is no absolute knowable truth.

74 Some discoveries are the direct result of planned investigations and are frequently based on the work of teams of scientists from several subject areas.

75 Some patterns are conceived only through insight, and not by gradual step-by-step, planned investigations. Whenever new phenomena do not fit existing patterns (currently accepted theories) preconceptions can hinder and delay progress.

76 Sometimes science advances by the interaction of theory and technology, each providing information or techniques which can be used by the other.

77 Modern scientific research is costly and requires team work. Large sums have been allocated to such enterprises.

78 There are more people currently engaged in scientific research than ever before in the whole history of science. One direct result is the greatly increased output of published scientific literature.

USE OF THE ABOVE THREE AREAS OF CONSIDERATION

79 The environmental scheme is coherent, logical and consistent with Project aims. It is the main source of ideas for inclusion in the Project materials.

80 Ideas that arise from consideration of the environmental scheme are, for the most part, ideas concerned with scientific knowledge and/or the nature of science. Subsequent consideration of the latter two areas gives rise to further ideas, appropriate to the schemes outlined, and suitable for inclusion with the environment based ideas in a topic for classroom study.

81 The latter two areas are used occasionally as the prime basis for inclusion of ideas. In such a case, an idea is included from one of the two schemes, and the other two are considered for further ideas that may be joined with the basic idea to fit into a suitable topic for classroom study.

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82 Some ideas are used as topic bases for reasons other than that they arise from the environment scheme, the six themes, or the nature of science as outlined. However, such instances are few in number.

83 When a topic has been nominated as suitable for development into a classroom unit, it and the ideas in it are judged according to a set of criteria. On the basis of these criteria, the topic is rejected or amended to meet the requirements. The procedures and criteria used are explained in detail in a separate paper.

38 (updates 4)
DEV/LEH/KR
9 October 1970

Australian Science Education Project

USE OF THE INQUIRY APPROACH

1 The Australian Science Education Project has resolved to produce materials aimed at encouraging inquiry, whilst developing skills and attitudes that will enable the individual to inquire efficiently and be able to resolve relevant problems. In this paper the use of the inquiry approach in ASEP materials is described. In outline, the discussion involves the following stages:

(a) an explanation of inquiry.
(b) the rationale for an inquiry approach.
(c) the place of content in an inquiry approach.
(d) the advantages and disadvantages of an inquiry approach.
(e) the role of the teacher.
(f) guidelines for material development officers.
(g) the inquiry approach in action.

What is the inquiry approach?

2 Essentially, to use an inquiry approach is to apply the processes of science. That is, inquiry will involve the individual in activities of identifyihg problems, observing, measuring, classifying, ordering, inferring, predicting or forming hypothesis, searching for and discovering meaningful patterns, designing and carrying out experiments, interpreting and analysing the data, and verifying the validity of the conclusions reached.

3 In the classroom situation these activities can range between two extremes - teacher-centred and student-centred situations. In the first of these the activities are controlled by the teacher (or an instruction manual); here the teacher (or manual) carefully directs the student towards a desired, pre-determined outcome. At the other extreme, control rests with the student. Here no direction or guidance is given and the final outcomes are not known in advance.

4 In addition to these two extremes of student inquiry, the teacher may inquire into his own teaching method. In this way, the teacher becomes aware of teaching as a dynamic process in which he observes the learners, collects data about them,interprets the data, makes diagnoses in terms of the learner, the situation and the goals, and finally modifies his behaviour in terms of these diagnoses.

5 Must inquiry only apply in an activity approach? We believe not. Inquiry includes the process of thinking. Sitting alone and pondering a problem without the aid of concrete props is another facet of inquiry. As we see it, inquiry involves a balance between thought and action.

What is the reason for using an inquiry approach?

6 The basis for presenting science as inquiry rests upon the following principles which we have accepted as working hypotheses.

We believe that

6.1 active involvement is superior to passive reception in learning.

6.2 learning occurs best when the situation stimulates without coercing and provides for success rather than failure.

6.3 to develop creativity and thought the student must be given opportunities requiring thinking and creativity.

6.4 students need to be taught the methods of scientific inquiry.

In placing an emphasis on the processes of science what will be the place of content?

7 Underlying statements made in support of the use of the inquiry method is the implication that "it does not matter whether the student learns any particular set of facts, but it does matter whether he learns how much fun it is to learn to observe and experiment, to question and analyse the world without any ready-made set of answers and without any premium on the accuracy of his factual results ....[1]". This implication has resulted in the claim that the use of the inquiry method over-emphasizes the processes of science and disregards the content. Such a claim will not be true of ASEP materials. A careful study of the Project aims, and the paper, "The Main Ideas in ASEP Materials" will show that in these materials the need for both process and content are satisfactorily considered.

The advantages and disadvantages of an inquiry approach

8 An advantage of an inquiry approach would be the favourable attitudes to science, and the behavioural changes which would follow. Some examples of these are as follows:

8.1 The development of attitudes which will predispose an individual to:

8.11 demand evidence in support of claims.
8.12 postpone judgment when available evidence is inconclusive.
8.13 change opinions in the light of [illegible]

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8.1 The development of attitudes which will predispose an individual to:

8.11 demand evidence in support of claims.
8.12 postpone judgment when available evidence is inconclusive.
8.13 change opinions in the light of incompatible data.
8.14 have confidence in tackling new problems.
8.15 seek rational explanations.
8.16 be receptive to change and flexible when required.
8.17 be persistent.
8.18 be critically tolerant of the opinion of others.
8.19 seek natural causes of observed phenomena.
8.20 be creative in his approach to problem solving.

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1 A.R. Hibbs : "Science for Elementary Students." Teachers College Record, 63, 136-142, (1961)

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9 The development of specific skills or abilities that will enable the efficient use of inquiry to the solving of relevant problems. These would include:

9.1 the ability to clearly identifying the problem.

9.2 the ability to use relevant resources.

9.3 the ability to plan and carry out an investigation.

9.4 the ability to collect and order data.

9.5 the ability to present information and communicate to others.

9.6 the ability to assess and extend the information obtained.

10 The development of such attitudes and behaviours could result in students who are more independent, systematic, empirical and inductive in their approach to life. These students would be better equipped to appreciate the nature of science and its role in shaping their everyday lives.

11 We believe that teaching science by inquiry can lead to increased motivation, longer retention of knowledge, increased transfer and more complete understanding of what science is. As a result we believe that students can be expected to continue work on similar or related problems long after the primary task has been completed. Though the available evidence is limited, experiments such as that reported by Hurd and Rowe[2], seem to show that an inductive inquiry approach is superior to traditional deductive methods, in that the cognitive achievement of students using this method match that of those using deductive methods, while their learning of the methods of science and their scientific attitudes are significantly superior. The superiority of the inductive method is due to it offering active involvement in learning and more meaningful experiences.

12 The disadvantes of an inquiry approach mainly apply to two areas - the content versus processes consideration, and the classroom practicality. On the first point the critics are numerous, and the following statements summarize their point of view:

> "the science curriculum should give the student a feeling for science as a selectively and sequentially organized structure of knowledge. This is no less important than imparting the view that science is a method of inquiry."[3]

> "it is also somewhat unrealistic to expect that subject matter content can be acquired incidentally as a by-product of problem-solving or discovery experience."[3]

> "the goals of the science student and the goals of the scientist are not identical. Hence students cannot learn science effectively by enacting the role of a junior scientist."[3]

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11 We believe that teaching science by inquiry can lead to increased motivation, longer retention of knowledge, increased transfer and more complete understanding of what science is. As a result we believe that students can be expected to continue work on similar or related problems long after the primary task has been completed. Though the available evidence is limited, experiments such as that reported by Hurd and Rowe[2], seem to show that an inductive inquiry approach is superior to traditional deductive methods, in that the cognitive achievement of students using this method match that of those using deductive methods, while their learning of the methods of science and their scientific attitudes are significantly superior. The superiority of the inductive method is due to it offering active involvement in learning and more meaningful experiences.

12 The disadvantes of an inquiry approach mainly apply to two areas - the content versus processes consideration, and the classroom practicality. On the first point the critics are numerous, and the following statements summarize their point of view:

> "the science curriculum should give the student a feeling for science as a selectively and sequentially organized structure of knowledge. This is no less important than importing the view that science is a method of inquiry."[3]

> "it is also somewhat unrealistic to expect that subject matter content can be acquired incidentally as a by-product of problem-solving or discovery experience."[3]

> "the goals of the science student and the goals of the scientist are not identical. Hence students cannot learn science effectively by enacting the role of a junior scientist."[3]

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2 P. de Hart Hurd and M.B. Rowe: "Science in the Secondary School" Review of Educational Research, June 1964. p.289

3 Ausubel, D: "The Evaluation of the Conceptual Schemes Approach to Science Curriculum Development," Journal of Research in Science Teaching, Vol 3, 255,64, 1965.

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13 These objections highlight the need for careful appraisal of inquiry approaches to science teaching. However, we believe that the criteria that have been adopted for the selection of subject matter should ensure a balance between both the processes and the content of science.

14 One objection to the widespread use of inquiry is that of practicality. Inquiry procedures will certainly be more time consuming, and possibly more expensive, so that teachers could be concerned with these difficulties.

15 There may be doubt about the extent to which the inquiry method can be efficiently used at all developmental stages. Some research* has shown that the inductive method, where students learned by directed self-discovery favoured above-average students while the lecture-demonstration, deductive method favoured the below average student. We believe that the inquiry approach should be used throughout the materials, but the degree of direction should be varied to meet the individual needs of students at each of the developmental stages.

The role of the teacher in an inquiry approach to science

16 One role of the science teacher must be to inquire into his own teaching. Teachers must be encouraged to apply the inquiry method as a means of self-examination of their own teaching behaviour. This examination involves locating what it is learners do when they inquire, and becoming aware of the behaviours the teacher exhibits that stimulates the learners to undertake inquiry. The teachers' inquiry into his science teaching will involve a systematic examination of his own teacher-behaviour in an attempt to extend his awareness of the range of, and consequences of, his behaviour upon a given group of learners.

17 The teacher can instil a sense of inquiry by becoming an inquirer himself. For example, he may not know the answer to a problem, but he may, with his students' help, study and resolve it. It is important that the teacher is not seen as a reservoir of knowledge. Students will enjoy having their teacher involved in discovering with them. By being an inquirer a teacher encourages healthy skepticism of authority. By continually asking for empirical evidence, not just opinion, he teaches inquiry by example.

Guidelines for ASEP Materials Development Officers

18 The preceding discussion has indicated the relevance of the inquiry approach to science teaching and in outlining the advantages and disadvantages of the method, several features emerge which lead to guidelines for the materials development staff. These are listed below.

18.1 It is recommended that no one method of inquiry be adopted by ASEP developers. Different approaches, e.g.

that the criteria that have been adopted for the selection of subject matter should ensure a balance between both the processes and the content of science.

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18.1 It is recommended that no one method of inquiry be adopted by ASEP developers. Different approaches, e.g. programmed instruction, guided investigation, demonstrations, unguided discovery, etc., should be provided at all stages of the child's intellectual growth, and the choice should be made on the basis of the desired outcomes. There has been inadequate research done for any decision to be made that at any one developmental stage, e.g. the concrete stage, a particular inquiry technique is more favourable than any other.

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* "Differences in treatment due to the stage of development" L.G. Dale (ASEP), and "Piaget's Theory of Intellectual Development" H. Ginsberg & S. Opper (Prentice-Hall) 1969.

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18.2 Inquiry can be used in achieving cognitive objectives but the use might be confined to activities in which a high degree of guidance is to be given. In designing materials aimed at developing processes, skills or attitudes, the method could be widely used. Activities should be planned which will involve the student in problem-solving tasks involving varying degrees of freedom from instructions to be followed.

18.3 For the student to be able to think and be creative he should be given opportunities requiring thinking and creativeness. This implies the need to produce materials that involve him in exciting and stimulating experiences. Materials must be designed in such a way that the student makes his own decisions, and to some extent chooses for himself the direction of further activities. In our opinion problem-solving skills are developed more efficiently in the presence of a high degree of student activity, responsibility, and decision.

18.4 The arguments put forward in favour of time-cost should be considered so that inquiry methods are not used exclusively when the same objective could be achieved in less time and with the use of alternative materials.

18.5 No matter what ability or behavioural change is to be achieved, this will only result from re-current experience. Materials should be designed to allow for repetitive use of problem - solving skills.

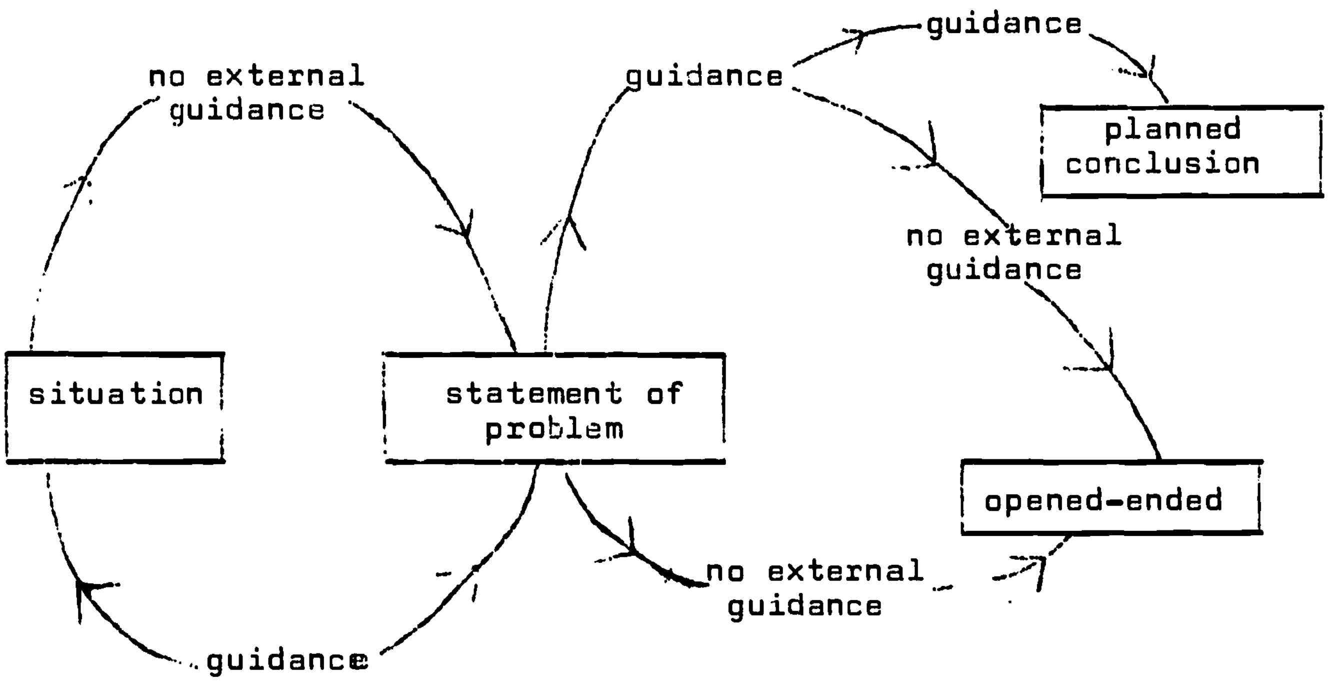
18.6 Materials should be produced to show some historical aspects of science, and to give the student examples of how a scientist has used inquiry. This approach will enable the nature of science to be better understood by the student, as he comes to appreciate the behaviour of scientists.

18.7 It must be stressed that the success of inquiry methods, even those that involve little teacher direction or control, still depend to a high degree upon the philosophy of the teacher. There is great danger in imposing a particular teaching procedure upon teachers who do not have the personal characteristics to use it efficiently. This is particularly true in programs which are essentially laboratory-centred. It is therefore recommended that in the preparation of the Teacher's Guide and in planning the Teacher Education program, considerable emphasis be given to the teacher's role in the use of the inquiry approach.

18.8 Consistent with 18.1 above, it is suggested that the materials developed for the first trials should incorporate a wide variety of learning procedures. Where an inquiry approach is considered desirable the selection of the type of activity should be determined by the nature of the materials and the objectives to be achieved.

The inquiry approach in action

19 The following diagram is a model which represents the range of activities in which inquiry is used:



20 In the model, situation represents any experience designed by the teacher or presented in the material, which is encountered by the student and which is motivating to him. (Note: Despite the fact that the situation may be planned in advance by the teacher, or the materials, this will not be considered as guidance.)

21 The statement of the problem is that stage in which a question is posed. The model indicates that the question may be the result of a decision of the student (no external guidance), or a decision made by the teacher, or text, etc., (guidance).

22 A planned conclusion is the solution to the question or problem which had been pre-detemmined before the situation was experienced.

23 Open-ended refers to the unplanned conclusion (theories, generalization, etc.) which were not anticipated when either the situation was planned, or when the statement of the problem was made.

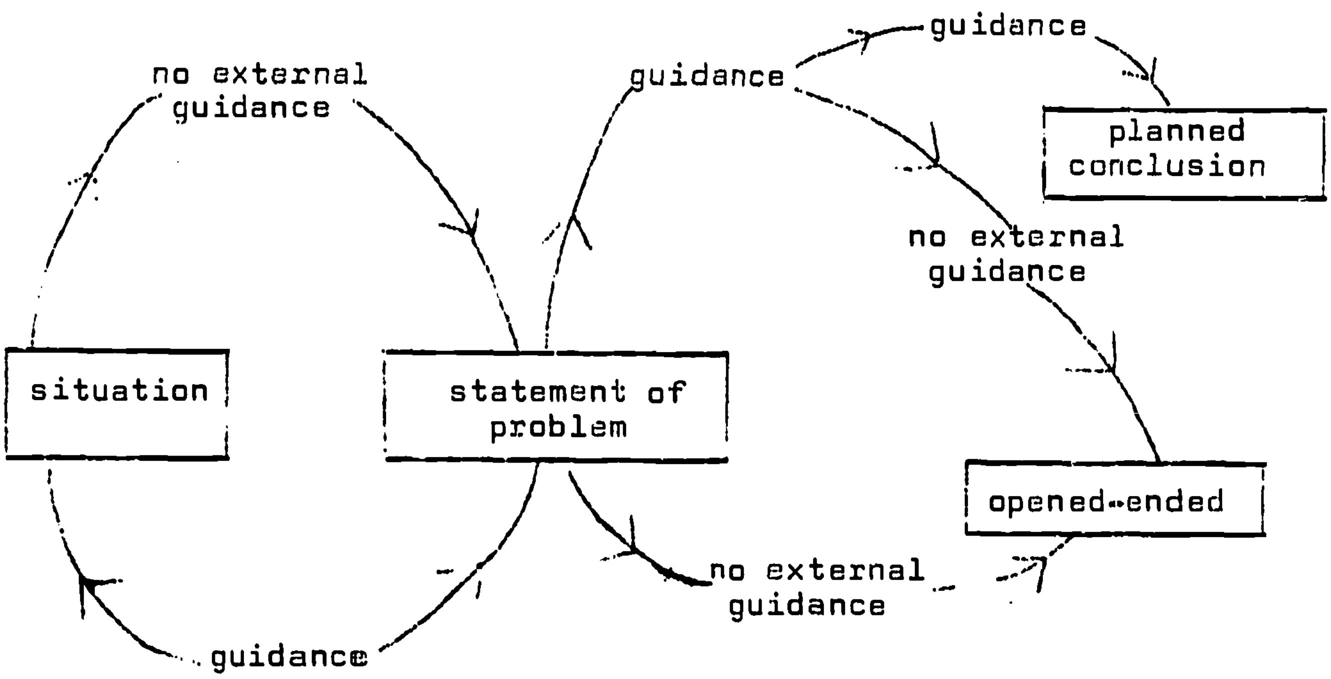
24 This model leads to six clearly defined inquiry activities which may be briefly summarized as follows:

24.1 Type A - fully guided activity after problem presented.

24.2 Type B - student poses problem, then complete guidance given.

24.3 Type C - student makes all decisions, no external guidance given.

24.4 Type D - similar to C, but some guidance is given of activities in which inquiry is used:



20 In the model, <u>situation</u> represents any experience designed by the teacher or presented in the material, which is encountered by the student and which is motivating to him. (Note: Despite the fact that the situation may be planned in advance by the teacher, or the materials, this will not be considered as guidance.)

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24.4 Type D - similar to C, but some guidance is given between posing the problem and reaching a conclusion.

24.5 Type E - open-ended: after initial problem is given, some intermediate guidance may be given.

24.6 Type F - open-ended, after problem is given there is no external guidance.

More detailed explanations of these activity types are given below. In each case illustrative examples have been given but these should not be taken to be indicative of ASEP materials.

25 Type A: Here the situation is presented to the student and he is continually guided to reach the planned conclusion. This model is typical of the activities in JSSP and many similar projects. It is essentially guided inquiry.

26 The following examples chosen from published science materials illustrate model Type A.

26.1 A text sequence - e.g. programmed instruction designed to establish quantitative relationships in proportion.

" One of the ways in which we gain knowledge of the physical world is to measure certain properties of physical events, and look for relationships between these properties. For example, pressure and volume are two properties of a gas, and we could look for some relationship between these quantities. What happens to the volume as we change the pressure?"

In this section we shall examine some of the methods by which such relationships are discovered and analysed.

1	The simplest relationship between two sets of measures is one of simple proportion. This means that if we double one quantity the second also doubles. Three times one quantity corresponds to ......times the other quantity.	three
2	The mathematical symbol for "is proportional to" is $\propto$. So W $\propto$ V is read W............V.	is proportional to
3	If V represents the volume of a piece of silver, and W represents the weight, then if we double the volume of the silver we would expect to .... its weight.	double
4	If we halved the volume we would ..... the weight.	halve
5	This type of relationship is known as direct proportion, and we say that the weight is .... to the volume.[4]	proportional

26.2 A directed activity - e.g. measuring directions, as in JSSP Card 201.

(The following is a quote from this card: "On your circle diagram, label North 0° and East 90° with small neat figures just outside the circle. Your diagram should now look something like this.")

4 N.Wilson: A Programmed Course in Physics, Form V. Teaching Part 1, Time, Space and Motion, Angus & Robertson Ltd. 1966, p.23

.......8

26.3 Using a model - e.g. how to use a mercury thermometer. JSSP Card 511.

(The following is a section of this card: "When you are using the thermometer make sure that the bulb at least is surrounded by the material being examined" - see diagram 4.)

It should be noted that in this type of activity only one problem or question is to be resolved. If part of the procedure involves a subsequent question to be answered, then either a new sequence has begun (situation - question - etc.) or the activity has become open-ended.

27 Type B: In this activity the student poses the question but then proceeds through guidance to the planned conclusion. Here the situation has been so contrived that all of the questions which the student could ask could be used to guide the subsequent activities towards the achievement of the planned conclusion.

28 Examples of this type of activity are the following:

28.1 The student is directed to heat a number of substances, which either melt, boil, or sublime. No question is posed but the class are asked to write down a number of wondering why questions which could be investigated further. Each question can then be investigated by the class, and through teacher guidance, the planned conclusion that"heat is needed to bring about a change of state" can be achieved.

28.2 The Chem. Study Experiment No.24 - The development of a logical model.

29 Type C: In this activity the student is the sole decision-maker. He receives no external guidance and is open to reach any conclusion, i.e. in the ultimate sense, Type C inquiry leads to new information through pure discovery.

30 For this type of activity the only prerequisite is the situation, which invariably will be "an exciting experience." In developing materials it is necessary to either suggest these experiences, or produce them, in the form of audio-visuals. The very nature of purely open-ended activities will severely limit their inclusion in ASEP materials, but their importance should not be under-estimated. They represent many of the experiences the student will encounter in his everyday life.

31 An example of Type C is the following: A stoppered flask, partly filled with a clear liquid, stands on the laboratory bench alongside a sign which reads, "please shake." On shaking the flask the student observes the solution to turn blue, and then after standing for a few minutes to again become colourless. On re-shaking the colour changes are repeated.

32 Type D: This type of activity, similar to Type C, begins with an exciting experience after which the student "states the problem" without any external guidance, and finally reaches an unplanned conclusion i.e. open-ended. However between stating the question and reaching a conclusion varying degrees of guidance are given either by the teacher, or manual, or similar resources.

33 An example is that in which a student initiates a research project of his own but at times seeks external guidance. The following also demonstrate the procedure:

33.1 The student is given a number of large ball bearings ($\frac{1}{2}$") and some of $\frac{1}{4}$" diameter and a long sloping track. He is directed to place some of the balls together and then allow other balls to impact with this group. He is not limited in the number of combinations he may try and can pursue any further activity he wishes.

33.2 Many of the research activities in the JSSP project or the excursions used in the ISCS project would also be examples of these open-ended activities.

34 Type E: This activity is also open-ended but differs from the previous type in the degree of guidance. Here the student is channelled in a specific direction by being presented with a specific problem to be studied. Following the statement of the problem the student is given some further guidance but is then able to proceed without additional external assistance to reach an un-planned conclusion. This type of activity will frequently appear as an off-shoot of an activity of types A or B, where after achieving the desired result, further questions arise which result in an open-ended inquiry.

35 For example the following typical laboratory activities all lead to Type E activity:-

35.1 In the PSSC Experiment III-3 the student is directed to carry out a specified activity using the Inertial Balance, but he is finally left with the problem "How could this device be used to measure the acceleration of an automobile?"

35.2 The student is directed to carry out a reaction between concentrated nitric acid and copper metal in order to study the process of oxidation and reduction. On completion of the experiment the following questions could be posed:

"Why did the solution become hotter?"
"What caused the solution to turn blue?"

35.3 Many demonstration lessons fall into this category in that several questions usually result from them, and in many cases the child is only given partial guidance towards a solution. In this type of activity the subsequent inquiry may be carried out without the aid of any concrete props.

36 Type F: In this activity the student is presented with the problem to be resolved but is then given no further external guidance.

37 The example quoted for Type C would apply here if the card had read "Why does this change colour on shaking?" The rhetorical question posed during demonstrations or in written material also give examples of this type of activity.

38 The following, taken from the Elementary Science Study topic "Mosquitoes" is a further example:

What Animal Do Mosquitoes Prefer to Bite?

Two scientists wantad to find out which animals one type of mosquito liked best to bite. They put a cow, a goat, a pig, a dog, a cat, a chicken, and even a man in a room and let mosquitoes in it. Later the mosquitoes were caught and the blood which each mosquito had eaten was looked at. Chemicals were used to test the blood to see which animal it had come from. The chart shows how many times the animals were bitten during the experiment.

Animal	Number of times bitten
cow	238
goat	125
pig	69
man	24
dog	17
cat	18
chicken	9

Why do you think cows and goats were bitten more than dogs and chickens?"

39 It should be noted that in all of the activities described there are two common features:

1 In each activity the student is required to make some decisions.

and 2 Each activity involves the student in some of the tasks of problem-solving.

i.e. a) stating the problem
b) carrying out an investigation
c) collecting data
d) organizing data
e) formulating an hypothesis
f) assessing his conclusions.

40 In practice it is difficult to prescribe an inquiry activity which only develops a specific ability, such as, the ability to assess information, and in fact the activities described would develop several of the abilities specified in the taxonomy. In the production of materials the Material Development Officers should be guided by the need to develop these abilities as well as the need to apply the inquiry method in the variety of ways described.

41 In addition, it is important to remember that problem-solving skills are developed by re-current practice. Therefore if it is intended to develop some manipulative skill related to problem-solving, such as learning how to locate information, then the student must be given adequate instruction in the skill and then given practice until the skill is achieved. Similarly, if we wish to develop the ability to analyse problems, or interpret evidence, then the skill must first be learned and then classroom situations frequently provided when an opportunity will be provided to use the skill. There is no easy way of teaching children to use the abilities of problem-solving other than setting classroom situations which call for their repetitive use. However it is not necessary that the student be presented with situations calling for the use of the <u>complete</u> problem-solving technique - beginning with the recognition of the problem and ending with a conclusion. The method does <u>not</u> have to be practiced in its complete cycle. It is quite possible, and even desirable, to plan activities designed to achieve only certain aspects of the technique, and this has been demonstrated in the examples chosen.

42 Further guidance in the use of the inquiry method can be obtained by reference to the papers where the clarification of ways dealing with subject matter is discussed.

REFERENCES AND READING

1 Hibbs, A.R., <u>Science for Elementary Students</u>. In Teachers College Record, Vol.63, 1961, 136-42.

2 Obourn, E.S. and Johnson, L.K., <u>An Analysis and Check List on the Problem Solving Objective</u>. In U.S. Department of Health and Welfare. Publication OE-29017

3 Hurd, P. de Hart and Rowe, M.G., <u>Science in the Secondary School</u>. In Review of Educational Research, June, 1964, p.289

4 Ausubel, D.P., <u>The Evaluation of the Conceptual Schemes Approach to Science Curriculum Development</u>. In Journal of Research in Science Teaching, Vol. 3, 1965, pp. 255-64.

5 Kersh, B.Y., <u>Learning by Discovery What is Learned</u>. In Arithmetic Teacher, Vol. 11, No.4, April, 1964, pp. 226-32.

6 Bruner, J.S., <u>The Act of Discovery</u>. In Harvard Educational Review, Vol.31, 1961, pp.21-32.

7 Ginsberg, H and Opper, S., <u>Piaget's Theory of Intellectual Development</u>, N.Y., Prentice Hall, 1969.

8 Bruner, J., <u>The Process of Education</u>, Harvard Uni. Press, 1960.

9 Romey, W.D., <u>Inquiry Techniques for Teaching Science</u>, Englewood Cliffs, Prentice Hall, 1968.

10 Sund, R.B., and Trowbridge, L.W., <u>Teaching Science by Inquiry in the Secondary School</u>, Columbus, Charles E.Merrill, 1967.

11. Anderson, H.O., <u>Readings in Science Education for the Secondary School</u>, New York, MacMillan, 1969

12 Thurber, W.A. and Collette, A.T., <u>Teaching Science in todays Secondary Schools</u>, Boston, Allyn and Bacon, 1959

13 Washton, N.S., <u>Teaching Science Creatively</u>, Philadelphia, W.B.Saunders 1967

Australian Science Education Project

A TAXONOMY OF ASEP OBJECTIVES

Pre-amble

The purpose of the taxonomy is to facilitate the classification of ASEP objectives within a framework that is both clearly defined and consistent with recent thinking in science education.

Several taxonomies were considered, including Bloom's taxonomy, the IEA Project list of teaching objectives for science, the BSCS testgrid, and the JSSP taxonomy. Of these, the Bloom, IEA and BSCS all contained aspects useful in the classification of ASEP objectives but no one system was considered to be completely satisfactory. (The Bloom taxonomy could not be adopted since it was found difficult to relate the categories specifically to science. In addition facility in using the taxonomy would be enhanced if the number of major categories was reduced to four.) The JSSP taxonomy, which was a modified form of the Bloom taxonomy, was considered to be satisfactory, if each of the sub-divisions were further itemized, and in the taxonomy presented this has been done.

The ASEP taxonomy is intended only to be used for the classification of ASEP objectives. It does not attempt to state which of these objectives are more desirable and should receive greater emphasis nor does it cover devices used by designers of the materials to facilitate achievement of the objectives.

In this classification, the following broad areas of learning are recognized:

Knowledge
Processes
Manipulative Skills
Attitudes

The four broad areas are interdependent and should be regarded as different facets of the same entity. Within each category the examples chosen are purely illustrative and do not imply ASEP objectives.

KNOWLEDGE

Knowledge is defined to include those behaviours and test situations which emphasize remembering, either by recognition or recall, of ideas, materials or phenomena.

The sub-classifications extend from the specific and relatively concrete types of behaviour to the more complex and abstract. Thus the knowledge of specifics refers to types of knowledge or information which can be isolated and remembered separately, while the knowledge of abstractions emphasizes the inter-relations and patterns in which the information can be organized or structured.

While it is recognized that knowledge is involved in the more complex major categories of the taxonomy, the knowledge category differs from the others in that remembering is the major psychological process involved here, while in the other categories the remembering is only one part of a much more complex process.

1 Specifics

Knowledge of separate pieces of information, qualitative or quantitative, which together constitute most of the bulk of scientific knowledge. Such information includes meanings of words which are part of the language of science, description of properties of things or situations relevant to science, statements concerning categories in classifications or positions in sequence and relationships between specifics.

Much specific knowledge is at a concrete level e.g. 'the disc rotated at 20 revolutions per second', but it can be quite abstract e.g. the definition of the term 'inertia', and so includes much of what is commonly known as 'concepts'.

The criterion for placement in this category is that the information concerns one specific instance, place, term, thing, structure, relationship, sequence or category whether or not the specific relationship, sequence or category is itself quite abstract in nature but provided that the information is not a statement of a generally accepted scientific principle or law. For example, 'energy' is an abstract term and a single statement concerning energy or energy relationships is a specific, but the statement of the principle of conservation of energy fits in category 2.[illegible].

1.1 Knowledge of Terminology

Knowledge of words and symbols used in science for concise description, including both the terms and their generally accepted definitions or meanings, and names of structures or things. The terms may be specific e.g. eye, day; or may refer to a category in a classification system e.g. mammal; or a sequence e.g. dichotomous branching; or a relationship e.g. reciprocal, second generation.

The criterion for placement in this category is that the information gives definite meaning to one term - a word or words, symbol or symbols used to represent one entity.

Examples:	thermometer		galvanometer
	Taurus	mammal	kidney tubule
	relative humidity	copper	octave
	potential energy	oxidation reduction	photosynthesis

1.2 Knowledge of Specific Facts

Knowledge of separate pieces of information, qualitative or quantitative, obtained by the application of the processes of scientific investigation or relevant to knowledge of science.

This category includes all specific information that is not Terminology.

Examples:

Taurus is the constellation between Aries and Gemini
Sound is transmitted by longitudinal wave motion of air particles
Mammals are vertebrates
Fish first appeared during Devonian times

2 Integrations

Knowledge of the ways of organizing, studying, judging and criticizing ideas and phenomena. This entails knowledge of the method of inquiry, the major ideas, schemes and patterns by which phenomena and ideas are organized, and the standards of judgement. This category does not include the actual ways and means - i.e. the processes, rather it is passive awareness of the existence and use of these processes.

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2.1 Knowledge of Methodology and Conventions

Knowledge of set methods of inquiry, techniques, and procedures employed in a particular field. Emphasis is on the knowledge of the method not on the ability to use the method. Thus before engaging on inquiry techniques the student will be expected to know about suitable methods; that is, objectives in this category are concerned with the ability to recognize or recall this knowledge. Ability to use the knowledge is categorized under Processes.

Examples:

How to use a mercury-in-glass thermometer
Where to use capital letters when writing genus and species names
Accepted abbreviations for scientific units
Designs of experimental investigations

.../3

Examples: (Continued)
- How to make a key for identifying invertebrate animals
- How to use a library reference to obtain relevant information
- Rules for laboratory behaviour
- How to evaporate a solution to dryness
- How to dissect a mammal

2.2 Knowledge of Patterns

Knowledge of systems of classification, general sequences and trends evident in scientific information or into which such information can be organized. The criterion for this category is that the knowledge concern whole systems of classification and complete sequences.

Knowledge of how to classify or to look for sequences and trends is included under 2.1. Knowledge of details concerning each class or relationships within a sequence or classification is included under 1.2. Ability to classify or determine trends or sequences is categorized under Processes.

Examples:
- The classification of elements into metals and non-metals
- The classification of insects into major orders
- The evolutionary sequence
- Classification of substances by magnetic properties
- Stages in the life of a radio-active substance
- Trends in the teaching of science over the past fifty years
- The life cycle of a frog
- The solubility curve for potassium chlorate for a specified range of temperatures

2.3 Knowledge of Abstractions

Knowledge of principles, laws, models and theories recognized by scientists (but not necessarily currently acceptable) and useful in explaining, describing and predicting.

Objectives in this category are concerned with recognition or recall of acceptable versions of the particular abstractions. Knowledge of specific instances or of relevant details is included in 1.2. Ability to form abstractions or to use them in new situations is included under processes and ability. Statements of generalizations from experimental results, e.g. metal oxides are basic, are included in 1.2.

Examples:
- Major principles such as equilibrium, etc.
- Newton's Laws of motion
- The principle of conservation of momentum
- The Rutherford Bohr model of an atom
- The theory of evolution
- The Lowry-Bronsted theory of acids and bases
- The Laws of Heredity
- The inter-relations between chemical principles or theories - i.e. enthalpy and entropy

PROCESSES AND ABILITIES

This area of the taxonomy covers ways in which knowledge of science is obtained, organized, interpreted and dealt with in various other ways. To some extent, success in the use of these processes, like ability to learn or recall knowledge, is dependent upon certain mental abilities that are common to all fields of learning. However, the taxonomy is based on the use of an inquiry or problem solving approach rather than upon the mental abilities involved.

Emphasis is on ability to use each process in situations relevant to and requiring some knowledge of science.

.../4

1 Ability to plan an investigation

1.1 The ability to use knowledge of science and of methodology in particular, to plan an investigation.

These include,

1.11 ability to plan such details as finance, equipment, services, space and time required for an investigation.

1.12 ability to design items of equipment for a specific purpose

1.13 ability to modify given equipment for a particular purpose.

1.14 ability to design the layout and assembly of a set of equipment.

1.15 ability to plan the sequences and procedures to be followed in an investigation.

1.16 ability to design and prepare tabulations for recording data.

1.17 ability to predict and avoid possible safety hazards.

1.18 ability to relate design of equipment to the theoretical problem

1.2 Ability to state the problem

This includes the ability to formulate the problem and state it firstly as a general intention then in concise form as a workable hypothesis. This includes the ability to

1.21 ability to identify the problem(s)

1.22 ability to identify necessary assumptions

1.23 ability to define clearly the quantities to be measured

1.24 ability to specify controls required for other variables

1.3 Ability to outline a procedure to be followed

The use of knowledge of methodology and of equipment to plan a suitable sequence of investigation using appropriate instruments and techniques.

1.31 The ability to plan the procedures required for an investigation

1.32 The ability to prepare tables for recording data

1.33 The ability to screen and judge the design of experiments

2 Ability to carry out an investigation

This is the next logical step in an inquiry approach although it does not preclude further planning as the investigation proceeds.

It involves the collection of relevant information and the analysis or organization of findings in the search for meaningful patterns or abstractions. It does not include the evaluation of the findings or statement of them or the physical manipulation of equipment.

2.1 Ability to assemble equipment

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2.1 Ability to assemble equipment

This would include the

2.11 ability to assemble and operate equipment according to known principles but without instruction

2.12 ability to dismantle, check, clean, pack and return, or dispose of equipment

2.13 ability to locate faults or isolate errors in the equipment

.../5

2.2 Ability to collect data

Relevant information can be obtained indirectly from verbal (oral or written) and audio-visual sources or by direct observation of actual things, equipment and situations. The physical manipulation of equipment is classed under Manipulative Skills. The use of simple measuring techniques such as reading a scale fits in this category.

This category includes

2.21 the ability to carry out measurements of such dimensions as distance, weight, volume, time and to estimate tenths of a scale division.

2.22 the ability to carry out accurate and prompt observations

2.23 the ability to make detailed observations

2.24 the ability to select and operate cassette films, microfilm and audio tapes

2.25 the ability to use reference sources

2.26 the ability to read material of appropriate reading difficulty with speed and comprehension

2.27 the ability to understand symbolic notations, and interpret data presented in tables and graphs

2.3 Ability to organize data

The ability to use known methodology in a search for patterns and relationships in data. This involves the use of such techniques as classification, tabulation, serial ordering, graphing, diagrammatic representation, statistical analysis in order to detect relationships between elements of data or between previous knowledge and elements of data.

This category does not include a critical examination of the organized data or the formulation of a statement of findings.

This category includes the:

2.31 ability to record measurements by numbers, written legibly, in an appropriate tabulation

2.32 ability to use audio and visual recording services, particularly tape recorder and camera

2.33 ability to make summaries and notes from reference material

2.34 ability to use a classification key for the identification of a specimen

2.35 ability to re-arrange data into tables or hierarchical sequences

2.36 ability to select appropriate scales for the graphical representation of a set of data

2.37 ability to substitute numbers into simple algebraic formulae

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2.35 ability to re-arrange data into tables or hierarchical sequences

2.36 ability to select appropriate scales for the graphical representation of a set of data

2.37 ability to substitute numbers into simple algebraic formulae to find an unknown

3 Ability to present information

The ability to communicate information by verbal (oral and written) and visual means (diagrams, drawings).

Emphasis is on the preparation of a communication for later use by the person concerned or by others. Techniques used for the organization of data (e.g. tabulation, graphing) do not fit into this category but the final product (graph, table etc.) may.

This includes the ability to:

3.1 ability to compose a systematic, carefully planned written report

3.2 ability to present a short verbal report

3.3 ability to contribute significantly to discussion in a small group

3.4 ability to contribute to a more formal discussion in a large group

3.5 ability to seek out people who may help in an investigation e.g. teachers, and be able to talk freely with them.

3.6 ability to ask questions of use in an investigation, without relying too heavily on a large amount of such assistance.

3.7 ability to represent data diagrammatically

3.8 ability to prepare geological or astronomical maps

4 Ability to establish new information

Ability to critically examine available information, to extend it and apply it to new situations and to integrate relevant portions into coherent statements.

Evaluation by critical examination is an essential part of dealing with knowledge of science and to some extent it comes into all categories of processes listed. In this category emphasis is on the evaluation and extension of information obtained or available. Evaluation of equipment and techniques and the design of new equipment and techniques is covered under category 1.

This category includes

4.1 Ability to Assess Information

The ability to use knowledge of science to locate possible sources of error and to determine, in consequence, the degree of confidence that can be placed in findings obtained.

4.11 ability to detect inadequate control of variables

4.12 ability to distinguish between observation, hypothesis and opinion

4.13 ability to distinguish the model from the observations the model was derived to describe

4.14 ability to identify inconsistencies in collected data

4.15 ability to extract from collected data evidence relevant to a given hypothesis

4.16 ability to compare hypotheses with accepted laws, observations and opinions

4.17 ability to identify the limitations within which any given hypothesis or law may be expected to apply

4.18 ability to recognize and eliminate common systematic errors, e.g. zero error

4.19 ability to understand the

teachers, and be able to talk freely with them.

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4.17 ability to identify the limitations within which any given hypothesis or law may be expected to apply

4.18 ability to recognize and eliminate common systematic errors, e.g. zero error

4.19 ability to understand the size of a number and the nature of its dimensionality

4.2 Ability to extend information

The ability to extend information beyond that already available by making inferences, changing the form or sequence, making estimates within a given pattern (system of classification, trend or sequence), or predicting beyond a given pattern, and by application to new situations. This category also includes the combination of relevant and significant information into patterns (systems of classification, major trends or sequences) generalizations, and abstractions (statements of principles, laws, models and theories). It is within this category that skills of creativity or imaginative thinking are classified.

.../7

4.21 ability to compare new data with previous data

4.22 ability to interpolate from known data

4.23 ability to extrapolate beyond known data

4.24 ability to apply scientific laws or principles to new or unfamiliar situations

4.25 ability to construct a theoretical model

4.26 ability to identify characteristics by which classes of objects may be specified

MANIPULATIVE SKILLS

These are the acts of physical manipulation which are essential in the conduct of scientific investigations.

Knowledge of things and equipment is included under the category, Knowledge of Specifics 1. Knowledge of the method or procedures used in handling things and equipment is included in Knowledge of Methodology, 2.1. The ability to communicate knowledge has been included under the category, Ability to Present Information, 3.

In this major area we are only concerned with classifying the ability to use materials and equipment. The category contains the manipulative skills which students studying science in grades 7-10 might be expected to have developed. For practical purposes the list of skills given as examples is not exhaustive.

Examples:
Dissection of a mouse
Using a spectroscope
Measuring temperature of a liquid
Blowing a bulb in a glass tube
Modifying a galvanometer for use as a voltmeter
Setting up equipment according to instructions given
Heating a liquid in a glass vessel
Accurate use of measuring equipment, including weighing
Transferring of liquids from one container to another
Using a bunsen burner or its equivalent
Using the microscope
Handling of dangerous liquids, solids and gases
Using soldering equipment
Preparation of a solution
Shaping glass tubing
Preparing microscope slides
Reading a scale
Wiring an electric circuit
Using sources of energy
Handling living things
Making observations using optical instruments
Assembling laboratory apparatus

ATTITUDES, VALUES, INTERESTS AND HABITS

This section of the taxonomy is concerned with patterns of preference for certain behaviours in given situations. The terms 'attitude', 'value' and 'interest' are vague and are interpreted in different ways by different authorities. In this taxonomy they are grouped together as orientations ...

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1 Values, Attitudes and Interests

These terms commonly refer to preferred orientations in thinking which may lead to chosen behaviours.

Example: A preference for statements supported by evidence, rather than for unsupported statements.

This may lead to a person seeking evidence for statements, or basing actions on a supported statement rather than on an unsupported statement.

Example: A preference for asking questions and investigating aspects of the environment.

2 Habits

These are tendencies to perform certain actions in response to the appropriate stimuli with little thought.

Examples: Recording observations promptly
Cleaning teeth regularly
Wearing a seat belt

Notes

1 The above categorization of processes according to stages in an investigation does not affirm that this is a necessary of even desirable sequence.

2 When classifying objectives from learning materials:

(i) All knowledge requiring recall and relevant to the field of science is classified under 'Knowledge'.

(ii) Objectives concerning the use of equipment will be categorized under both Manipulative Skills and Processes.

(iii) Where there is doubt concerning the categorization of an inferred objective the alternative categorization should be given in brackets.

3 When classifying objectives from test items:

(i) Most test items test more than one objective. The main objective of each item should be emphasized by underlining. Where doubt occurs, alternative categorizations should be given in brackets.

(ii) For multiple choice items, initial categorization should be based on the correct answer to the item. Following this, categorization of the other distractors could also provide useful information on their consistency.

(iii) A good test item is written so that there is negligible difficulty in reading the item or understanding what it relates to. Difficulty should be related only to determining the correct answer. Obviously bad items should be listed as such and need not be categorized.

43 (updates 27)
DEV/LD/VK
20 November 1970

Australian Science Education Project

PREPARATION OF SECOND SPECIFICATIONS OF A UNIT

The following description of second specifications is intended as a guide to developers. Different units will be specified in different ways but developers should include all relevant aspects described below. Actual headings and layout used are at the discretion of the developer.

Main heading

ASEP

DEV/developer's/
initials
(date)

SECOND SPECIFICATION OF A UNIT

Title ..(in caps)........... (unit number) ....

Stage .... Specified by: (developer's initials) ....

Discussant: ....

Research Officer: ....

Estimated length .... 40 minute periods

1 If a minimum length of time is needed, for example, for growth of plants, this should be stated here also. The estimated length of each part of the unit should be shown at the beginning of the description of each part or on the flow chart.

What the unit is about

2 Write an introductory paragraph, stating briefly what the unit is about, in the form of what the students will do. This should be a succinct summary of the unit.

Relevance to the environment scheme

3 The ideas to be included should be stated clearly, giving attention to aspects of man as an individual or man as a group member, extensions of the senses, effects of technology and the natural environment. Statements should be brief but the section is important as the environment scheme is the main basis of selection for most of our units.

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The main science ideas included

4 These should be stated briefly but clearly. Where possible you should stress their links with the six themes listed in Document 36. Ideas involving the nature of science should also be included.

Useful background knowledge and abilities

5 State briefly what background is assumed. You may decide to write a portion of the unit to cover this background but it should be stated nevertheless.

Links with other units

6 State which units provide useful background and which units develop further the ideas contained in this unit.

Knowledge objectives

7 Those to be developed specifically by this unit should be stated clearly, including new terminology, procedures and integrations.

Process, ability and attitude objectives specific to this unit

8 These should be stated clearly but broadly, where applicable.

Detailed plan

9 The activities to be followed by students and teachers should be outlined broadly but in sufficient detail to give the reader a good idea of the ways in which the developer will attempt to achieve the desired outcomes.

10 A flow chart of student activities, showing clearly the positions of the core activities, core development activities, research activities, remedial activities and evaluative devices, and how students will be occupied during waiting periods, if any, for example, when waiting for plants to grow. The time estimated for each activity and the size of student groups involved could be included. If they are not included here they should appear later in the more detailed outlines.

11 A plan of the content and sequential development of the core materials.

12 An outline of the core development activities in which each activity is briefly described.

13 An outline of relevant research activities (open-ended). These could be included in the core development activities.

14 A statement of how students should record their work.

15 An indication of the position of remedial activities in the overall plan and the type of remedial activities to be included, if any.

16 An indication of the position and type of evaluative devices to be included.

17 A brief description of the class activity designed to round off the unit in such a way that achievements are shared and satisfaction is gained by all students.

18 A clear indication of the form of the materials e.g. printed verbal, diagrammatic, film, chart, etc.

References and audio-visuals

19 A list of available audio-visuals that could be used by teachers and/or students to supplement the ASEP materials.

20 A list of readily available references suitable for student or teacher reference. A brief description of each (one or two sentences) should be included. This list need not be exhaustive at this stage but its compilation should require a reasonable search of the literature.

21 A further list of references with a brief description of each, which are not necessarily readily available but could be useful for follow-up reading. This list need not be long. List only those items known to you and which could be useful.

Facilities required

22 A brief description of the classroom facilities needed, in terms of whether a laboratory is essential, or a classroom with certain services, or a classroom with no facilities, or certain field situations.

23 A preliminary list of equipment and materials (e.g. specimens) needed. Where it is intended that special equipment should be developed this should be clearly stated and the purpose of such equipment briefly described. Quantities should be stated as required for a class of 40 students. Equipment assumed to be normally readily available should be listed but very briefly e.g.'beakers, burners, evaporating basins will be required.'

Style

Throughout the specifications the style followed should be that set out in Project Document 30.

Document 20

54
DEV/LD/VK
17 May 1971

Australian Science Education Project

RE-ALLOCATION OF UNITS FOR DEVELOPMENT

Since we issued the list of titles of approximately 50 units that we intended to develop, it has become obvious that we must reduce this number to give a more realistic estimate of our possible output.

Current calculations indicate that we shall be able to develop 40 units and possibly several more. Accordingly, in this document the 40 units that we intend to develop are listed. Six other units are listed, in order of priority of development.

Many units have been re-numbered to give unbroken sequences.

Stage 1 units to be developed (17 altogether)

*	101	Messengers	
*	102	Mice And Men	
*	103	Working In A Laboratory	
*	104	Cells And Replication	(originally 213)
*	105	The World Of The Soil	
*	106	Male And Female	(originally 214)
*	107	Pigments And Acidity	
*	108	Pushes And Pulls	
*	109	Signals Without Words	(formerly 121)
*	110	Made To Measure	
*	111	Electric Circuits	(formerly 120)
*	112	Little Boxes	(formerly 119)
*	113	Plants	
*	114	Minerals And Crystals	
*	115	Water	
*	116	Rocks Formed From Sediments	
*	117	Energy And Change	

Stage 2 units to be developed (14 altogether)

*	201	Microbes	(formerly 221, originally 106)
*	202	Sticking Together	(formerly 217)
*	203	Light Forms Images	
	204	Making Life Easier (Simple Machines)	
	205	Getting Into Gear (Clothing)	(formerly 222)
*	206	Energy For Life (Food)	
	207	Fossils -- to be a short unit	
*	208	Life In Fresh Water	

Stage 2 (Contd.)

*	209	Australian Landscapes	
	210	Australian Seashores	
	211	Winds And Weather	
*	212	Inside The Earth	
	213	Models (Atomic Structure)	(formerly 220)
*	214	Charge	(originally 104)

Stage 3 units to be developed (9 altogether)

*	301	Populations	
	302	Traffic	
	303	The Human Machine	
*	304	Genetics	
	305	Big Molecules	(formerly 312 Plastics plus 213 (308) Fibres)
	306	Metals In The Service Of Man	(formerly 310 plus 311 Search For Raw Materials)
	307	Solar Energy	
	308	Where Humans Came From - to be a short unit	(originally 205)
*	309	Controls	

Units to be developed if time permits

These are listed in order of priority.

1.	215	Give And Take (Electro-magnetism)	(formerly 216)
2.	216	Spreading Force	(formerly 202)
3.	217	Supporting Structures	(formerly 219)
4.	118	Insects	(formerly 112)
5.	310	Evolution Of Continents	(formerly 305)
6.	311	The Universe	(formerly 306)

Units previously listed which have been omitted from the above list.

109	Sound	- covered by a JSSP unit
111	Temperature	- covered by a JSSP unit
117	Sand Castles	(originally 218)
201	Drugs	- possibly will be developed externally
205	Skin	- to be incorporated into 205
213	Fibres	(originally 308) - to be incorporated into 305

215	Intrinsic Properties	- part, at least, to go into 216
218	Colour	(originally 117)
311	Search For Raw Materials	- incorporated into 306
312	Plastics	- title changed to Big Molecules
313	Learning And Unlearning	

Current state of development

Asterisked units have been started and are at various stages of development at the time of writing this paper.

The first trials of units 101, 102, 103 and 105 have been completed or almost so.

Unit 201 is undergoing first trial.

Units 107, 113, 202 and 214 are in various stages of production.

Units 108, 109, 114, 203 and 208 are almost ready for production.

Units 104, 106, 110, 111, 112, 115, 116, 117, 206, 209, 212, 301, 304 and 309 are in various stages of preparation of manuscript for production.

Document 21

SER/GR/GM
16 July 1971

Australian Science Education Project

A PLAN FOR THE SECOND TRIALS OF UNITS

Introduction

1 The second trials of ASEP materials differ in many respects from trials undertaken by other projects. ASEP does not have a total package of materials nor a complete text to be tried in some predetermined order. It is not possible to evaluate a total program of ASEP and the total effect on children. Such evaluation must await the availability of a total package and a time scale of at least four years to make this possible. For the second trials the maximum number of units any one teacher can try with any one group of children is five. This represents only a small proportion of a total of (say) 35 units which may be used eventually to service a school curriculum.

2 The second trials of units are an essential part of formative evaluation. The information to be gathered is designed primarily to give evidence concerning changes to be made in the materials in the light of classroom trials in all States. Because of the relatively small number of units to be tried in any given class, only limited evidence may be gathered on the effects a total program of ASEP materials may have on students and on teachers.

3 There are many unknown factors when a trial of the extent envisaged is proposed for the first time on the Australian education scene. The Project has made a number of decisions based on the limitations of its own resources. It offers to the State Advisory Committees recommendations for a possible course of action to be followed during the period of second trials.

4 The plans proposed may be too demanding of the resources of the States, or, from the experience gained from other trials of materials in the various States, they may not appear rigorous or extensive enough. The Project will need alternative courses of action if what is proposed does not meet the needs of the individual States. The Project believes, however, that it can meet its own requirements from the program outlined, and sustain the effort needed for implementation.

The Purposes of the Second Trials

5 The validity of the final form of the materials and the extent of their eventual adoption in schools will depend to a large degree on the outcomes of the second trials. Thus the second trials may be used to serve three main ends:

5.1 to ensure the validity of the materials for Australian schools

5.2 to provide a nucleus of teachers experienced in ASEP philosophy and the use of ASEP materials who may help with the introduction of the published materials in the various States

5.3 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.

6 The more specific purposes of the second trials are:

6.1 to determine the suitability of the various units in different classrooms

6.2 to refine the content, structure and presentation of each unit based on evidence gained from the trials in the various States

6.3 to explore different combinations and sequences of units and their effects

6.4 to find out specific needs of the various States and to modify units where possible to account for these

6.5 to establish or confirm necessary pre-requisites for teachers and students using a particular unit

6.6 to determine sources of equipment and aids for the units in the various States

6.7 to develop checklists and other supporting materials to help the teachers more effectively introduce ASEP units into schools

6.8 to provide a group of teachers experienced in the use of ASEP units.

7 It is anticipated that some States may wish to use the introduction of ASEP materials for purposes other than the ones listed above. This is to be encouraged provided the servicing of any additional purposes does not place added strain on ASEP resources. For example, a State may like a wider trial of a particular unit than the Project can afford to provide. Arrangement could possibly be made to provide plates for that State to print its own copies. Alternatively, the materials provided could be re-used with another set of classes.

The organization of second trials

8 The Project is convinced from its first trial experience that, in the formative evaluation stage, more effective feedback is obtained if the closest possible liaison exists between the trials teachers and the Project. The model to be introduced for second trials extends this idea within the limitations of a wider trial. It is hoped eventually to extend the model for the final introduction of ASEP materials so that rarely will a teacher using ASEP materials have to go it alone.

9 The Project proposes that the SAC appoint a "trials co-ordinator" in each State to co-ordinate the second trial in the State for the SAC and the Project. The success of the second trials, and the success of the eventual introduction of ASEP materials will to a large degree depend on the enthusiasm and the ability of the trials co-ordinator. He must, for example, be in complete accord with the aims, purposes and philosophy of ASEP.

10 The success of the trials co-ordinator will largely depend on the amount of time he can spend working on ASEP matters. There will not be an even commitment of time, but it is anticipated that on an average 1½ days per week will be needed to do an effective job. It is likely that the trials co-ordinator's work-load will increase as more and more units become available. The duties of the trials co-ordinator are set down as an appendix to this paper (Appendix A). He will be responsible to the Project for supplying feedback and to the SAC for the progress of the trials.

11 The Project also proposes to organize the second trial of each unit in each State in teams. Each team should consist of a "team leader" who will co-ordinate and participate in the trial of a unit. The Project expects the team leader to occupy a position as science co-ordinator (senior master, subject master, science master, etc.) in a school, be well qualified and have an active interest in the teaching of science. The duties of the team leader are set down in Appendix B. It is anticipated that he will be responsible directly to the trials co-ordinator for the trial of the particular unit in his State.

12 The success of the trial of each unit in each State will depend very much upon the professional competence of the team leader. It is anticipated that while his team is actually trialling a unit, the team leader will be allowed about one day per week to work on ASEP matters. The team leader will participate as a trial teacher as well as an organiser.

13 The remaining members of the team will be selected according to criteria to be given later in the paper. They should be representative of junior secondary science teachers in the various systems. It is anticipated that each member of a team will have about a half-day per week free to work on ASEP matters. The duties of a trial teacher are given in Appendix C. A diagram showing lines of communication for the people involved in trials is shown in Appendix D.

<u>The extent of trial of each unit</u>

14 It is impossible in the design of a trial of this nature to account for all the variables which may influence the outcome. Indeed, if experience from overseas projects is any indication, irrespective of school system, student ability, or State, the teacher is the most important determinant of the outcomes of the instructional process.

15 In the design of the second trials, it is intended to take some account of the following variables in the trial of each unit:

15.1 differences among teachers

15.2 differences in ability and interest among students

15.3 differences among States

15.4 differences among class types

16 From the trial of a total package of units it is hoped to gather some evidence on how the following may affect the introduction of ASEP units in schools:

16.1 differences among school systems, e.g. State, independent Roman Catholic, and other independent schools, or country vs metropolitan

16.2 class size and composition

16.3 school facilities

16.4 existing State syllabuses

16.5 different sequences of units

17 For each unit, the following distribution of classes and teachers is desired:

	NSW	VIC	QLD	SA	WA	TAS
No. of classes (and teachers)	4	4	3	3	3	2

In addition to the above, four competent teachers, as shown from their performance in first trials in Victoria, will do all units in their second trial form to act as a control. Also, an extra two sets of materials will be offered in NSW for trial in two classes at a centre separate from the main trial - perhaps in a country area. This scheme gives a total of 25 classes trialling each unit - an absolute maximum in terms of the Project's in-house capability to service.

The selection of classes for trialling each unit

18 Project materials are being developed for three stages of intellectual development. From our surveys of States each State does make some attempt at an ability grouping within a grade level. This is more clearly identified in some States than others. In the design, it is presumed that the States can identify up to three ability levels within each grade level. It does not particularly matter which criteria are used for this selection. For example, ability level 1 means above average or higher stream, ability level 2 means average or middle stream (or unstreamed), and ability level 3 means below average or lower stream. The preciseness of these divisions should be determined for each State according to the class selection procedures which prevail in the State.

19 The following distribution of classes for trial at each stage is suggested for the various States:

Stage I materials

Grade level	7 (Form 1)	8 (Form 2)	
Ability level 1	✓		
2	✓	✓	for NSW, VIC
3		✓	

Grade level	8	
Ability level 1	✓	
2	✓	for SA, WA, QLD
3	✓	

Grade level	7 (Form 1)	8 (Form 2)	
Ability level 1	✓		
(two only) 2		✓	for TAS

Each check mark represents a different class with a different teacher.

20 The pattern for the trials of materials for the other stages is similar to that for Stage I.

Stage II materials

Grade level	8 (Form 2)	9 (Form 3)	
Ability level 1	✓		
2	✓	✓	for NSW, VIC
3		✓	

Grade level	9	
Ability level 1	✓	
2	✓	for SA, WA, QLD
3	✓	

Grade level	8 (Form 2)	9 (Form 3)	
Ability level 1	✓		
2		✓	for TAS

21 Stage III Materials

Grade level	9 (Form 3)	10 (Form 4)
Ability level 1	✓	✓
2	✓	✓
3		[✓]

for NSW, VIC

(For Stage III materials, an extra class and teacher may be required so that all ability levels at Grade 10 (Form 4) are tried).

Grade level	10
Ability level 1	✓
2	✓
3	✓

for SA, WA, QLD

Grade level	9 (Form 3)	10 (Form 4)
Ability level 1	✓	✓
2		[✓]

for TAS

(For Stage III materials, an extra class and teacher at Grade 10 (Form 4) may be required).

22 If an extra teacher is required for a team trialling Stage III units, the Project will supply an extra set of materials and the team should be increased by one member.

The selection of teachers for the trial of units

23 Each group of teachers, either two, three, or four, depending on the State, is considered as the team for trialling the unit in the particular State. Each team should consist of:

23.1 a team leader - a competent science co-ordinator

23.2 a fully-trained teacher (4 year trained) with a science degree and at least three years' teaching experience

23.3 a trained science teacher just out from teachers' college

23.4 a trained teacher who is teaching science, but who is not a fully-trained science teacher with a minimum of three years' teaching experience e.g. one who has less than four science units, or only two years' experience.

24 In WA, QLD and SA delete the teacher identified as 23.2 from each team. In TAS, delete the teacher identified as 23.2 and, if possible, alternate 23.3 and 23.4 from team to team.

25 In the selection of the members of a team, no special recognition need be made of the various school systems, except that the proportion of State school classes to Roman Catholic school classes to other independent school classes over the total second trial should be as close as possible to the proportion of these schools in the State total. The proportions for the various States are, roughly:

	NSW	VIC	QLD	SA	WA	TAS
State Secondary	6	4	5	6	4	7
Roman Catholic	4	3	3	2	3	2
Other Independent	1	1	1	1	1	1

If these proportions could be more or less maintained for the total trial sample, then sufficient regard is being paid to the various systems.

26 In the selection of individual teachers for a team, the following further guidelines are suggested:

26.1 The team leader should be a volunteer from any of the school systems. Final selection of the team leader should rest with the SAC.

26.2 The remaining members should be selected by the team leader, in consultation with the trials co-ordinator, from other schools in reasonably close proximity to his own. These teachers should simply be prepared to do the job if asked.

26.3 The principal of each school concerned should be willing to offer a class as a trial class and be prepared to allow the trials teacher the required time off from school duties in addition to what would normally be allowed.

It is the responsibility of the trials co-ordinator to see that the proportions of teachers from the various systems over the total period of trial is about that quoted in para. 25. It is also the responsibility of the trials co-ordinator to ensure that the team leaders he selects are in various regions representative of important differences of student type in that State. For example, one team may be metropolitan high socio-economic, another, inner-city, the third, large country town.

Tentative time-table for second trials

27 Experience with our first trials teachers has shown that a period of training is essential if trials teachers are to cope with the exacting task of evaluating ASEP materials. To effect this, a series of workshops in the various States is proposed over the period of trial. These are incorporated in the following tentative time-table.

27.1 September-October, 1971	Visit of trials co-ordinators to ASEP headquarters.
27.2 October, 71-February, 1972	Workshops of three days' duration for trials teachers in the various States. Two ASEP staff members to attend.
27.3 February-July, 1972	Seven Stage I and two Stage II units become available for trial.
27.4 July-August, 1972	Second round of workshops of three days' duration, for new group of trials teachers. One ASEP staff member to attend.
27.5 July-November, 1972	Seven Stage I, two Stage II and four Stage III units become available for trial.

27.6 October, 1972-February, 1973	Third round of workshops of three days' duration for new group of trials teachers (if necessary) No ASEP staff to attend.
27.7 February - April, 1973	Five Stage I, eleven Stage II, and five Stage III units become available for trial.

28 At this point it is not necessary to go into detailed planning beyond the requirements of teachers and teacher education workshops for the period October, 1971 - July, 1972. Only plans for 27.1-27.3 inclusive, need be discussed. A proposal sequence of events for organizing the first part of the trials is given in Appendix E and the requirements for teacher education in Appendix F.

Numbers of teachers required to service the first part of second trials

29 It is appreciated that it may be difficult to select late in 1971 teachers to trial units at a specific grade level in 1972. However, we believe there is enough stability of staff in a sufficient number of schools for this to be done. It is our intention to provide teachers with units to trial in alternate months. Thus, a teacher receiving a unit for trial in February 1972 can expect the next in April 1972, about eight weeks later.

30 The timing of school holidays may delay this procedure in May and September of any year. Also, it may be seen that it is not possible to provide a given teacher a total program of work for a term or a year, so trials teachers will need to have other science material programmed to fill in the gaps.

31 During the workshop each teacher will be allocated the unit he is to trial, and will have worked through its first trial version, so he will have a good idea of the content he will be expected to teach. This should help teachers in preparing their science programs for the year.

32 For the period February - July 1972 it is anticipated that for Stage I units three teams in each State will be required and for the Stage II units one team is required. To be certain that there are sufficient teams trained to cope with the number of units, an extra team at each stage is proposed. This will also cope with the eventuality that one or other of the original teams may have to disperse. These spare teams, should they not be wanted for second trials, will be given one of our first trial units which they can try with their classes.

33 The distribution of classes and the composition of teams are given in paragraphs 17-22. When the team leader of each team has been selected, the remainder of the team should be selected to conform to the grids and the other requirements given in those paragraphs.

34 The total number of teachers needed for the trial of units during the period February - July 1972 is:

NSW 36 teachers (one team of four and one team of two six times)

VIC 48 teachers (two teams of four six times - 24 Project trial,
24 external trial)

QLD 18 teachers (one team of three six times)

SA 18 teachers (do.)

WA 18 teachers (do.)

TAS 12 teachers (one team of two six times)

These numbers include a satisfactory number of spares.

35 The suggested overall breakdown of teachers per grade per ability level is given below. The allocation of classes to different socio-economic and geographic groups is not shown but will be worked out later in consultation with the trials co-ordinators.

NSW (one team of four and one team of two per unit)

Grade	7 (Form 1)	8 (Form 2)	9 (Form 3)	
Ability level 1	8	4		
2	4	10	4	
3		4	2	
Total teachers	12	18	6	36

VIC (external trial)

Grade	7 (Form 1)	8 (Form 2)	9 (Form 3)	
Ability level 1	4	2		
2	4	6	2	
3		4	2	
Total teachers	8	12	4	24

QLD SA WA

Grade	8	9	10	
Ability level 1	4	2		
2	4	2		
3	4	2		
Total teachers	12	6		18

TAS

Grade	7 (Form 1)	8 (Form 2)	9 (Form 3)	
Ability level 1	4	2		
2		4	2	
Total teachers	4	6	2	12

36 The teachers in the grids presented in paragraph 35 will be those required for the workshops in 1971-72.

Conclusion

37 The fine detail for each State from the general pattern presented in this paper for the second trials should be worked out when the trials co-ordinators from each of the States meet at Glenbervie later this year. What is required of SACs is their approval of the general pattern as presented and their agreement to participate in the trials to the extent suggested in the paper.

38 The trials co-ordinator will be a key person for the success of the trials. A consultant, or an inspector with consultant role, or a person from a State curriculum and research branch, or a university or teachers' college person who might be able to use the research as part of a degree are all possibilities. The SACs are advised to give considerable thought to the selection of this person, and to see that adequate time is made available for him to do an adequate job.

39 The system outlined in the paper places a large degree of autonomy on the SAC and on the teachers involved in the trials. The Project believes this to be an important key to the future success of Project materials.

APPENDIX A

Suggested duties of the trials co-ordinators:

1 Co-ordinate all aspects of the trials in the State

2 Make direct reports to the Project on the progress of the trials

3 Act as liaison officer between the Project and the SAC for the trials

4 Help in the selection of team leaders, and give advice to team leaders on the selection of teachers for the various teams

5 Be responsible for distribution of materials and information from the Project to the team leaders

6 Be responsible for forwarding feedback from team leaders to the Project

7 Help in the training of team leaders and trials teachers

8 Organize regular meetings of team leaders and provide information about these meetings to the Project, and where required, to the SAC

9 Make and maintain contact wherever possible with pre-service and in-service training organizations in the State so that teachers in training and in the schools become familiar with ASEP and its materials

10 Provice information on the progress of trials to science teacher associations and other interested organizations.

It is expected that an allowance of an average of 1½ days per week will be made available to the trials co-ordinator to cope with his task.

It is essential that the trials co-ordinator be fully in accord with Project philosophy and aims and be prepared to promote ASEP activity within the State.

APPENDIX B

Suggested duties of team leaders:

1 Co-ordinate all aspects of the trial of the particular unit allocated to the members of his team

2 Arrange regular meetings with the other members of his team during trial of the unit

3 Provide advice and help on the trial and other matters for the members of the team

4 Communicate direct to the Project or to the trials co-ordinator on specific problems encountered by the team

5 Be responsible for collating and returning all feedback on the unit to the trials co-ordinator

6 Report to the trials co-ordinator on the success of the trial

7 Arrange distribution of materials to his team members

8 Act as a point of liaison so that teachers and others interested may see ASEP in action

9 Teach a trial class.

It is expected that the team leader will have the equivalent of one day per week off during the period he is trialling a unit to cope with matters related to the trial.

The effectiveness of the trial of each individual unit will depend very largely on the team leader. During the period of trial the team leader should become increasingly familiar with the approach and philosophy being adopted by ASEP. Team leaders will become key figures in the success (or otherwise) of the adoption of the final published materials.

APPENDIX C

Suggested duties of trials teachers:

1 To undertake the trial of an ASEP unit, following as closely as possible the requirements as set down by the Project in its materials and those of the team leader

2 Undertake to meet regularly with the team leader during the period of trial of the unit

3 Prepare feedback information for the Project and return it to the team leader

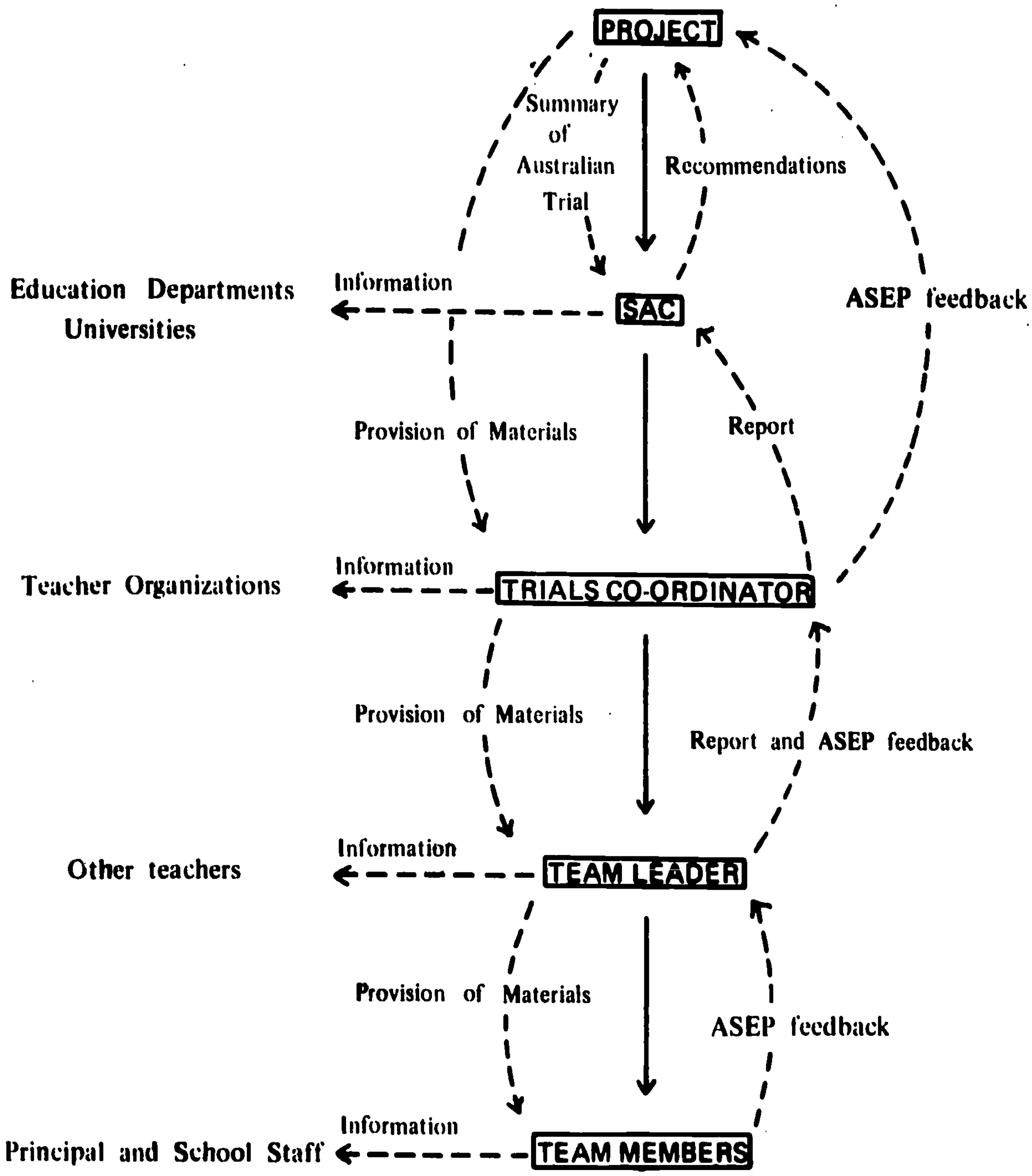
4 Report to his school principal and to the team leader on the success or otherwise of the trial

5 Act as a point of liaison on Project matters for members of staff at his school.

It is expected that each trials teacher will be given a half-day free per week during the period of trial to cope with ASEP matters. This would be in addition to any normal provisions in the school.

APPENDIX D

LINES OF COMMUNICATION FOR SECOND TRIALS



APPENDIX E

Proposed sequence of events for organizing second trials:

1 The trials co-ordinator is selected as soon as possible

2 The trials co-ordinator spends one week at the Project (Possible dates 6-10 September)

3 While at the Project the trials co-ordinator plans the second trial phase for his own State, including possible areas for trial

4 Immediately on return to his home State the trials co-ordinator selects the team leaders, either by calling for applications or asking selected suitable persons to volunteer

5 By 15 October, 1971 the trials co-ordinator has his first meeting with his team leaders. The team leaders, with the co-ordinator, select possible schools and teachers for the members of the team

6 By 15 November, 1971 the teams for the trials are selected

7 During the period 22 November - 10 December 1971 three-day workshops are held in the various States. If the November-December 1971 period is not suitable for the workshop in a particular State, it may be held in February 1972, although this may delay the start of the trials. SACs should communicate as soon as possible with the Project regarding the most suitable dates for workshops in the period 22 November - 10 December 1971, or January - February 1972.

APPENDIX F

Teacher education for second trials

1 This is Phase II of the planned Teacher Education Program which was mailed to State Advisory Committee members in April 1970. Stage 1 of this Phase II, an introduction to ASEP - its history, structure, purposes and aims has taken place in various ways in all States. The introduction consisted of:

1.1 Mailing to all schools of an information brochure, and Newsletters Nos. 1 & 2; Newsletter No. 3, which is currently being distributed, considers the development stages of a unit, trials and evaluation

1.2 Some articles in science teacher association journals

1.3 Talks by ASEP staff at conferences, CONASTA, and science teacher and departmental meetings

1.4 Visits by ASEP staff for series of in-service education conferences with science co-ordinators and educational officers in the States.

Orientation to ASEP (Stage 2 of this second phase)

2 The members of the State working parties and, to a lesser extent, these science co-ordinators and others (education officers, etc.) who attended the one-day conferences, have been orientated to ASEP through a number of activities. The need for discussions between teachers in the schools throughout Australia and ASEP staff (generally teachers seconded to the Project) is very important. The one-day conferences provided an opportunity for such discussions to begin and the good response of the participants in returning questionnaires has assisted the Project. It is important that teachers and educators know certain facts about the Project and that they have the opportunity to contribute to it.

Familiarization with ASEP

3 This is the task facing State Advisory Committees and ASEP in teacher preparation for the second trials.

The following teacher education plans are submitted for comment. In particular, each State Advisory Committee is asked to:

3.1 Name the State Trials Co-ordinator who will be able to attend a preparatory planning orientation workshop for second trials at ASEP from 6 to 10 September 1971

3.2 Indicate (and if possible, make suitable contact with) the appropriate person re Departmental and other approval for leave as specified below:

3.21 leave for trial co-ordinators to

(a) come to ASEP in September (one week)

(b) organize and attend three-day workshop later in 1971 or early in 1972

(c) perform duties of a trials co-ordinator (an average of one and a half days per week during trials in 1972 and 1973)

3.22 leave for team leaders to

(a) attend three-day workshop later in 1971 or early in 1972

(b) perform duties of a team leader (one day per week during trials)

3.23 leave for team-members to

(a) attend three-day workshop

(b) perform duties of a trials teacher (one half-day per week during trials)

3.3 Indicate the most suitable dates for the three-day workshop in terms of Appendix E

3.4 Select and make initial contact with the most suitable venue for the workshop

3.5 Consider the above items and reply to ASEP, if possible, by 16 August.

ASEP assistance

4 One or two ASEP staff members will be made available to attend each workshop and work with the State Advisory Committee team, helping to organize the workshop. The preparatory planning-orientation workshop for trials co-ordinators in September will be used to discuss and determine the most appropriate and effective ways in which ASEP and the SAC can co-operate during the second trials.

SER/GAR/KC
23 July 1971

Australian Science Education Project

CHECKLIST FOR UNIT DEVELOPMENT AND PRODUCTION

This checklist has been prepared for the guidance of MDOs and other staff members involved in the development and production of a unit. It gives the general order of the process, and indicates responsibilities at the various steps.

Final responsibility for all phases of the development must rest with the MDO. Any errors of fact or content, or typographic errors will have been approved by the MDO prior to the unit going to print.

1 Name of unit: ....
2 Developer: ....
3 Discussant: ....
4 Research Officer: ....
5 Date of commencement of development (arranged by ADD)
6 Preparation of second specification
Refer to Document 43, Preparation of second specification of a unit.
Initial meeting of MDO, DISC and RO to discuss unit: ....
Rough outline of second specification handed to DISC: ....
Rough outline of unit objectives handed to RO: ....
Draft second specification submitted to DISC and RO: ....
Second specification sent for typing: (100 copies) DUE DATE:
Actual date: ....

Evaluation of second specification

7 Date for evaluation meeting arranged by MDO with ASE: ....
8 Copies of second specification distributed

CHECKLIST FOR UNIT DEVELOPMENT AND PRODUCTION

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Draft second specification submitted to DISC and RO: ....

Second specification sent for typing: DUE DATE:

(100 copies)

Actual date: ....

Evaluation of second specification

7 Date for evaluation meeting arranged by MDO with ASE: ....

8 Copies of second specification distributed by MDO, together with copies of unit evaluation form 1a, to:
all DEV staff D ADS ASE RO1 RO2
ASPRO AVO TLO and ASTES ....

9 Evaluation meeting held on: ....

Attendance: ADD ASs MDO RO others interested.

Summary of proceedings made by RO.

...2

10 Post evaluation discussion

MDO DISC RO ....

Modifications of second specification agreed on.

Possible outside consultants listed.

Tests and evaluation of the unit planned.

Research needs for the unit planned.

Tentative plans for layout and audio visuals discussed.

Special production or audio visual requests passed on to AVO and ASPRO.

Recommendations for grade level of trial classes made to RO.

Development of unit

In co-operation between MDO and DISC, with assistance from ASPRO, AVO, ASTES and RO.

11 As requirements for illustration or photography become known, these are sent on the appropriate form. Request for Photography/Illustration to ASPRO. Date photos or illustrations are required is to be indicated. MDO to keep a dated copy of these requests. ....

12 As requirements for other audio visuals become known, these should be discussed by MDO, DISC and AVO. A memo should be sent by MDO to AVO. ....

13 As special requirements for equipment become known, these should be discussed with ASTES. A memo should be sent by MDO to ASTES

agreed on.
Possible outside consultants listed.
Tests and evaluation of the unit planned.
Research needs for the unit planned.
Tentative plans for layout and audio visuals discussed.
Special production or audio visual requests passed on to AVO and ASPRO.
Recommendations for grade level of trial classes made to RO.

<u>Development of unit</u>

In co-operation between MDO and DISC, with assistance from ASPRO, AVO, ASTES and RO.

11 As requirements for illustration or photography become known, these are sent on the appropriate form. <u>Request for Photography/Illustration</u> to ASPRO. Date photos or illustrations are required is to be indicated. MDO to keep a dated copy of these requests. ....

12 As requirements for other audio visuals become known, these should be discussed by MDO, DISC and AVO. A memo should be sent by MDO to AVO. ....

13 As special requirements for equipment become known, these should be discussed with ASTES. A memo should be sent by MDO to ASTES. ....

14 Manuscript should be written by MDO in consultation with DISC. As each part is prepared, MDO should pass it to DISC for reading. Refer to Document 47, <u>Preparation of manuscripts</u>. MDO to determine reading levels of script - see Document 7, <u>The provision of differences in reading abilities</u>.

Provide for differences between students - see Provision of differences between students, DEV/JL/VK, 8 June 1971. ....

15 A specific design for the evaluation of the unit is to be produced jointly by MDO and RO:
Based on this design, the MDO and RO will produce

15.1 all student tests and checklists for the unit;

15.2 checklists for teachers;

15.3 evaluation questionnaire for trials teachers (4a), specific to this unit (to accompany unit evaluation form 3a);

15.4 questionnaires for ASEP staff who will be visiting trials classes of this unit;

15.5 questions for external evaluators of the unit materials (to accompany unit evaluation form 3a). ....

16 Tests prepared for the unit to be panelled with MDO DISC ASEV RO1 and RO2. This meeting to be arranged by RO. Tests to be approved by ASTES ....

17 Corrected manuscript prepared. All pages to be numbered. Each separate item to be clearly identified. Manuscript to be approved by DISC. Sent to typing pool (4 copies)

DUE DATE:

Actual date: ....

18 MDO to write letters requesting permission to print any outside materials in the unit. Information on sources from LIB AVO PHOT. (File SER 3-4) ....

...4

19 List prepared by MDO of all materials to be produced by ASEP for this unit:

* student books
* record books
* teachers guides
* charts
* projectuals - movie film, 35 mm transparencies, overhead projectuals.
* special equipment
* all evaluation devices specific to this unit (see 15, above)

Copy of this list given to DISC ....

20 Copies of typed materials for unit returned to MDO, DISC and ADD. Copy of materials list (no 19 above) also given to ADD. ....

21 Discussion between MDO, DISC and ADD on typed materials. ....

22 Corrected typed materials prepared by MDO. Check that all pages are numbered, and that all separate items are clearly identified. Retyping done if necessary.
One copy to RO
One copy to DEV file
One copy to EDITOR DUE DATE:

Actual Date: ....

23 List of Apparatus, equipment and aids for trial schools (yellow form) to be filled in in duplicate by MDO. One copy to ADD, MDO to keep a copy. ....

24 Components of first trial units (white form) to be filled in in duplicate. Copy to TLO; MDO keeps one. ....

25 Distribution of materials. Names of all people whom MDO wishes to receive inspection sets to be given to TLO on the appropriate form. MDO to keep a copy. ....

...5

26 MDO checks that a copy of all typed materials plus second copies of all forms go into DEV file ....

27 Editor arranges time for ED and MDO to discuss manuscript. ....

28 Editor completes first edit, marks caps, italic and symbols, and bold, passes material to ASPRO for typesetting. ....

29 MDO and editor proof-read typeset copy (repro). ....

30 Rough made, using repro. ....

31 ASPRO with MDO designs unit materials (working with repro rough). Clear directions for art work are given. Two photostats are taken for PHOT and MDO. ....

32 ASPRO assigns additional photos and art work,
MDO present to check correctness of science concepts when PHOT takes relevant photos for unit,
MDO checks sketches and diagrams, and photo proofs for accuracy. ....

33 ASPRO gives book roughs to EDITOR for re-edit. LIB checks typeset references. MDO re-reads and makes (any) alterations. MDO checks his alterations with EDITOR. ....

34 Captions are decided by EDITOR and MDO using PHOT suggestions. ....

35 EDITOR and MDO return re-edited 'book rough' to ASPRO for final typesetting and paste up. ....

36 Final typesetting - in final art work form - including captions are proof read by EDITOR and MDO. Final approval given. ....

37 ASPRO, ADS approve art work for printing. DUE DATE: [ ]

Actual Date: ....

38 PRINTER prints art work to numbers provided by TLO and to quality check by ASPRO. ....

...6

39 Printed sheets sent to COLLATION,
Quality check ASTES. ....

40 Class sets and inspection sets
prepared and distributed by COLLATOR
under direction TLO. ....

41 Equipment and audio visuals provided
for trials classes by AVO, TLO.
Trial materials ready for
schools. DUE DATE:

Actual Date: ....