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ABSTRACT

This digest provides annotated bibliographies of articles published in THE AUSTRALIAN SCIENCE TEACHERS' JOURNAL from May 1955 to December 1973. Subjects included are: the place of science in the curriculum, scientific literacy, organization of science programs, current general science courses, current junior science courses, current senior science courses, suggested general changes, suggested particular changes, curriculum development, and new emerging curricula. A synopsis and a discussion are included in each section. (SL)

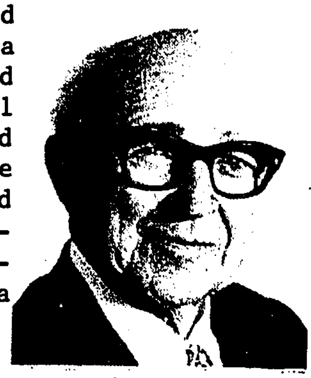
No.9

SOME ASPECTS OF SECONDARY SCHOOL SCIENCE IN AUSTRALIA

By Roy Stanhope

THE AUTHOR

Following attainment of his pre-service teaching qualifications from the University of Sydney in the 1920's - B.Sc. with a double major in Chemistry and Dip.Ed. - Mr Stanhope then taught science, and mathematics early on, in a wide variety of boys' and comprehensive co-educational high schools in both city and country areas. Two or three years of after-school and vacation studies in the Chemistry laboratories of the University of Sydney led to a research M.Sc.



During 1939-40 after a year of postgraduate work at Stanford University, Mr Stanhope lectured in Chemistry, Physics and Science Method in the Sydney Teachers' College. After a further period in the schools, finally as Deputy Principal of a large boys' high school, he returned to the College where, from 1951 to 1967, he was Head of the Chemistry Department.

Mr Stanhope represented, first the Secondary Teachers' Association and later all the New South Wales teachers' colleges, on the State Science Syllabus Committees for many years. At international science education conferences in Canada, America and Bulgaria he has represented the Australian Science Teachers' Association of which he is the only living Honorary Life Member. Since 1967 in recognition of his pioneering and continuing activities in this association the principal address at each annual conference has borne the general title: The Stanhope Oration. In further recognition of his services to science education Honorary Life Membership has been conferred by both the Australian and British science teachers' organisations, while he is a Fellow of the Australian College of Education.

Other pioneering efforts have included the construction and standardisation of an Australian Chemistry Test (the first in English outside the United States) and radio broadcasting in the Australian Broadcasting Commission's school science sessions. Mr Stanhope has published widely in federal, state and overseas journals.

Association with Macquarie University has continued since its first classes began in 1967, apart from lengthy overseas visits in 1968 and 1974. In some years he was on the full-time or part-time staff of the School of Education and in others on full-time science education research. The latter contributed to a Macquarie M.A. in Education in 1974.

SOME ASPECTS OF SECONDARY SCHOOL SCIENCE IN AUSTRALIA

The Place of Science in the Curriculum
Science for the Citizen - Scientific Literacy
The Science Program and Its Organisation
Current Courses in General
Current Junior Science Courses
Current Senior Science Courses
Suggested Changes in School Science Generally
Suggested Changes in Particular Sciences
Moves for a National Curriculum Development Body
New and Emerging Science Curricula

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Appreciation is expressed to Professor E. Richardson for his advice and encouragement during the course of this exercise.

SOME NOTES CONCERNING THE COMPILATION OF THE BIBLIOGRAPHY

Source of Digests

Articles published in The Australian Science Teachers' Journal from Vol. 1 No 1 (May 1955) to Vol.19 No 4 (December 1973) inclusive were the source materials.

Digests have been made of 84 articles, totalling 451 pages in the Journal, although many more articles were perused in search of material falling within the categories listed on the title page.

Categories

Of the several schemes considered for classifying the contributions that adopted seemed to have the greatest merit. However, the categories used are not mutually exclusive since in but few of the contributions have the authors confined their discussion to a single aspect of science education. Because of the specificity of the topic, contributions about scientific literacy and science for citizenship have been grouped in a separate category, although they could quite well have been placed under "The Place of Science in the Curriculum".

Within each category the digests are arranged in chronological order of publication date.

Headings

In an attempt to give a clearer indication of the subject matter discussed headings, sometimes different from those appearing in the journal, have been supplied for each digest; these headings are those used in the list of contents. Most of the sub-headings in the digests were not present in the original papers.

Arrangement Within Digests

In condensing contributions an attempt has been made to preserve the essence of the author's statements, i.e. to avoid distortions or incorrect interpretations. In a few cases clarifying or corrective notes have been added where thought desirable or necessary.

Time Lag

A time lag of variable duration occurred between the date of preparation of an address or article and the date of its publication, and also between these dates and that of the compilation of the digest. In some aspects of science education changes in situations, some quite fundamental, have occurred in the intervals.

Cross References

Other than identifying contributions to particular symposia or to a special theme cross references have been kept to a minimum.

Author Index

An author index follows the last digest.

Abbreviations

ACER	= Australian Council for Educational Research
ASEP	= Australian Science Education Project
ASTJ	= Australian Science Teachers' Journal
Br.	= Brother
ASTA	= Australian Science Teachers' Association
BSCS	= Biological Sciences Curriculum Study (USA)
CHEM Study	= Chemical Education Materials Study (USA)
CONASTA	= Annual Conference of ASTA
Ed.	= Editor or collator of a journal section
ESCP	= Earth Science Curriculum Project (USA)
HPP	= Harvard Project Physics (USA)
IPS	= Introductory Physical Science (USA)
ISCS	= Intermediate Science Curriculum Study (USA)
JSSP	= Junior Science Curriculum Project (Aus.)
PSSC	= Physical Sciences Study Committee (USA)
Rev.	= Reverend
Sr.	= Sister
Web of Life	= Australian adaptation of BSCS materials

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THE PLACE OF SCIENCE AND OF PARTICULAR SCIENCES IN THE CURRICULUM

1. *General Education and the Place of Science*

Neal L.F. (1961), Science in Education, ASTJ, 7,1, 4-8 (May)

Synopsis

In this paper discussion is centred on some of the problems of general education - where should it be given, specialisation and the stage at which it begins. Neal believes that the chief purpose of the school is general education and that external pressures must not be allowed to deflect it from this purpose. The present domination of the secondary curriculum in many schools by mathematics and science is deplored. Science deserves a place in school education but should not dominate it.

Discussion

Science is as important to man's spiritual nourishment and growth as music, literature, and art. From an arrogant and disdainful scorn of science in education not long ago, the situation has been so changed that sometimes today the products of science monopolise schooling. Some secondary school curricula in Australia are so illiberal and unbalanced that throughout most of a fairly short secondary schooling more than half the time is spent on mathematics, physics and chemistry, and sometimes no time at all on languages, the social sciences, music, and so on. Such activity constitutes training, not education. It is possible that despite the time given to mathematics and science, it is not these that are being studied, but an unmanageable and uncomprehended mass of material. Such a curriculum solves the dilemma of the two cultures by offering neither.

Two kinds of answers are given in England as to who is to be responsible for general education, of which science should form a part. Some say the universities, others the schools. From the way most English universities arrange their courses, it is rather obvious that they consider general education to be the responsibility of the schools, but by their own admission requirements they prevent the schools from doing so. This difficulty is also found in Australia. Neal considers that 'general education is the prime, peculiar and principal prerogative of the school', from which it should not be deflected by pressure from any external source. For instance; many boys, some girls, and numerous parents believe that man's contributions in literature, art, music, history, and law are unimportant by the side of mathematics, physics, ıd chemistry. This is a poisonous educational heresy to be vigorously ɛsisted.

In England, some schools have failed to remain true to their prime ısk - general education. Whereas thirty or so years ago, five years : general education preceded specialisation in the Sixth Form, nowa- ıys the division between the two cultures is being forced upon pupils :ten after only two or three years of secondary schooling. Alleged ɛasons for this early specialisation are cited. Complaints about the ɛcessive content of science syllabuses are being made both in England ıd here. Neal again criticises the unjustifiable monopoly of the ɛcondary school curriculum by science and mathematics in Australia - ɛelve periods a week of maths and five each of physics and chemistry : the age of twelve in some schools hardly seems evidence of a sound ɛneral education.

'Science should be in school education; but subservient to it and ɔt determinant of it. We are men before we are scientists or anything .se'.

2. *The Place of Science in Education*

Bassett G.W. (1961), The Place of Science in Education
ASTJ, 7,3, 13-16 (November)

Synopsis

Science has an important place in the school curriculum because its great significance in the modern world and because of its in- insic appeal to many pupils. Science, however, should not be given re time in school, but that now given it used more effectively by an proved teaching force. (Concrete suggestions as to science offerings d curricula are not given).

Discussion

Reference is made to the traditional cleavage in English educat- nal circles between 'academic' studies and 'useful' studies cluding the relatively unheeded admonition in the Spens Report of 37 that a better balance between humanistic and scientific studies s needed. In America the schools have placed great emphasis on the oduction of a particular type of social personality. England, erica, and Australia, greatly concerned over the great advances in ience and technology being made by Russia, are presently engaged in critical reassessment of their educational systems, with particular ference to science education.

Separating educational and political issues and setting aside the 'panic' aspects of the Russian-induced situation two judgments of the greatest significance can be made. These are:

1. there is an urgent need, because of the current concern with science, to make children and adults aware that few, if any, of the social problems confronting us can be solved by science and that humanistic studies embody ideas which have always been important and are even more important now; and

2. science is of such importance in the world and has such inherent appeal to many young people that its importance in school curricula must be accepted.

Science teachers, having recognised the first, could make their greatest contribution in working out the implications of the second. Science courses appropriate for non-science students and for specialists need consideration. Many science teachers see science as being only the latter and are critical of General Science courses as consisting of 'only a collection of odds and ends, leaving the student with a proper grasp of nothing'. Nevertheless the ordinary person must look to science teachers generally to impart to them a general understanding of science in the modern world. But this ordinary person is not getting much help at present. The author's concluding statement, insofar as school science offerings and curricula are concerned, is that given in the concluding part of the synopsis.

3. *The Place and Status of Science in the Curriculum*

Paterson I.W. (1971) Why Teach Science?, ASTJ, 17,4, 67-72 (December)

Synopsis

Science is one way of looking at the data of nature, producing a body of tentative knowledge. Science is only one of the several ways of interpreting the elements of human existence. The unity of knowledge and experience has been seriously unbalanced by the growth of science. The school curriculum has remained relatively fixed, with the result that pupils continue to lose interest in their schooling, questioning its relevance. Science should be taught as a discipline and as part of the 'ecology' of experience and knowledge. It cannot exist independently of other realms of knowledge. First priority in curriculum reform should be the development of interdisciplinary approaches to the solving of problems relevant to us all.

Discussion

Science: Its Meaning and Place in the Curriculum

Paterson's discussion of the meaning of science leads to his statement: 'Science, then, is a process of constructing bodies of tentative knowledge (content) and of discovering ways of making the physical world understandable'. The place of science in the school curriculum is thoroughly justified because much of our thinking relates to physical things and our understanding of them.

Status of Science in the Curriculum

The position and status of science in the curriculum remains moot. Phenix's classification of knowledge into six realms of meaning, each comprising a number of disciplines, is introduced (in tabular form) to enable science to be positioned within these realms and to assert its status by implication. A curriculum should include at lease one discipline from each knowledge area; that of the 'Empirics' embracing the physical sciences, the life sciences, psychology and the social sciences.

One of the obligations of education is to cross the barriers and boundaries of compartmentalised bodies of knowledge. The fragmentation and narrow specialisation in science has advanced exponentially its store of knowledge, far outpacing advances in other realms. In consequence the 'ecology' of knowledge has been seriously imbalanced.

The success of science has produced in other areas the domination of rational-technical views over the moral-philosophical views pre-eminent in earlier periods. Hence the 'ecology' of being and knowing has been sharply upset.

Implications for the Teaching of Science

The curriculum (that which is intended to be taught or learnt) of the different elements in education has been by far the least subject to scrutiny, debate and discussion. Over the years the curriculum has remained relatively fixed, familiar and marked by careful boundaries. Of the various attempts to effect change none, except perhaps the 'New' Mathematics, has been fundamental. Hence pupils continue to be motivated by coercion, to lose their joy in learning shown in infants' schools, to question the relevance of much of their studies, and to leave school unprepared for life. There is little advance towards the perfectibility of Man as pupils leave school behaving no less selfishly as has always been the case.

Science should firstly be taught as a discipline - a special way of looking at phenomena, with emphasis on process rather than content. Secondly, it should be taught as part of the 'ecology' of experience and knowing; seeking its proper place to preserve an ecological equilibrium.

The development of interdisciplinary approaches to relevant problem solving should be a first priority in reform. Some relevant problems, arising from the experience of us all, are listed.

4. *Astronomy: A Largely Neglected Subject*

Carey H.K. (1959), Astronomy - It Could Star as a School Subject, ASTJ, 5,1, 61-63 (May)

Synopsis

While astronomy, judging by the place given it in the four separate junior secondary science syllabuses in New South Wales, is suitable only for the less gifted students it is not only an important science but one which is of verifiable intrinsic interest to children.

Discussion

The Physics syllabus doesn't mention astronomy. The syllabus for Combined Physics and Chemistry, followed by the great majority of average and above-average students in State schools, includes a small non-examinable section on 'The Universe Around Us'. In contrast the Alternative Science course for below-average pupils suggests an allowance for astronomy of about one-fourteenth of the total lesson time for the three years.

Ample opportunity is given in astronomy for practice in individual observation. To this end detailed suggestions are given for a program of 'homework' extending over a period from the fifth or sixth week of the first term in first form until the end of the year. Mention is made that as the observations proceed questions arise which need answering. Often the author has found that little formal teaching is necessary since wonder and interest often run ahead of the program so that pupils seek answers for themselves from the library.

5. *A Plea for the Teaching of Astronomy*

Bok B.J. (1964), An Astronomer Looks at Science Education, ASTJ, 10,2, 29-39 (August)

Synopsis

The major portion of this paper is devoted to descriptions of the various efforts being made in the United States to improve science teaching in secondary schools. After presenting an argument for the teaching of astronomy in Australian schools an outline is given of the topics suitable for a course.

Discussion

The desirability of the inclusion of the study of astronomy in Australian secondary schools is argued on two grounds. In the first place Australians, young and old, are proudly aware of the great advances in radio astronomy and in optical astronomy made by Australians. In the second place we have a particular obligation to study the heavens because we have an access to the Magellanic star clouds and to parts of the Milky Way denied people in the northern hemisphere.

An outline is then given of a course in astronomy using a blend of the observational and historical approaches. The kinds of optical instruments preferred for the observational work by pupils are listed. Reference is made to the fact that a number of basic facts and laws of physics will be learnt during the study of astronomy, and their applications, for example in space travel, appreciated. Not only will this link with physics be forged but with chemistry also, particularly when the use of the spectrograph, the source of the sun's energy, and life in other worlds are being treated.

In case some may feel that the course as outlined means too much astronomy and astro-physics at the secondary school level, the author states that what he has outlined, and even more, is now to be found in physical science courses in some of the better Australian schools. The abstractor believes that Professor Bok is in error in such claims, particularly that in 'the Queensland syllabus ten periods per week per year are set aside for astronomy in each of the eighth, the ninth, and the tenth grades'. In fact the time allotment to science - covering astronomy, biology, chemistry, geology and physics - for the pupils taking the maximum of science in Queensland is 2.9 hours per week in Grade 8 and 4.7 in each of Grades 9 and 10 (Shepherd and Robins (1970).*

* Shepherd S.R. and Robins G.W. (1970), Around the States, ASTJ 16,1, 83 & 85 (May).

6. *The Importance of Biology to All*

Stephenson W. (1961), The Place of Biology in Secondary School Education, ASTJ, 7,1,1, 11-14

Synopsis

Although biological subjects are desirable for students proceeding to Medicine and may count towards university entrance (in Queensland at least) the real justification for teaching biology in schools is that it is involved in so many aspects of modern life that with no knowledge of the subject no one can claim to be properly educated.

Discussion

Biology is first defined and then the reasons given (as outlined in the above synopsis) for its importance to pupils likely to proceed to a university and to those not likely to so do. A statement is then made of the vicious circle - the university refrains from making biological subjectscompulsory for matriculation because there are very few teachers capable of teaching them, there are very few good biology teachers because it is not a compulsory subject.

Suggestions, at some length, are then given of the approaches that could be used in teaching some aspects of modern life in which a knowledge of basic biological facts is necessary. These suggestions concern Atomic Warfare, mainly the genetic effects of radiations; Human Populations, the 'explosion' and its control; and Teenage Problems, particularly sex education.

Of the two possibilities - biology as a separate subject or biology as an ingredient in General Science - the author prefers the former, other things being equal. Incidentally, the ideal elementary introduction to biology is by nature study or natural history up to about the age of 14. Illustrations are then given of how two themes in General Science, 'Oxygen' and 'Light', may be developed in the biological side.

The final point made is that if the choice is between no biology in secondary schools (as at present) and biology in General Science then the author is a staunch supporter of General Science.

7. *The Values of School Biology*

Ralph B.J. (1962), Why Teach Biology?; ASTJ, 8, 1, 23-25 (May)

Synopsis

This contribution was summarised by the author as follows. 'Our society is based largely on the mental attitudes of science and on the material benefits which flow from its application. The teaching of biology in our schools can assist in bringing awareness of the bases of our society, in inculcating the mental attitudes of science, in providing some knowledge of the biological part of the natural environment and in sparking an interest in careers in the biological sciences and their applications'.

Discussion

In attempting to justify the inclusion of a given subject in particular curricula two main considerations emerge, firstly the general education value of the subject and, secondly, its utilitarian value. In the cases of the subjects discussed in this symposium on 'What is the Philosophy of Education underlying the Science Syllabuses?' little argument is stated to be required on the matter of utilitarian value. Instead discussion ensues on the general educational value of biology in schools, the argument being initiated by using a biological analogy, the remarkable ways in which an organism, or even parts of an organism, react to environmental influences so as to survive or to make best uses of the available resources. Following this analogy the suggestion is made that 'for any individual in a human society to be well-adjusted, well-educated and cultured ..... the most important consideration is the cultivation of an awareness of the more significant factors which have moulded his particular society and which have brought about the adaptations characteristic of it'.

The two related factors which have had important roles in producing our environment are the development of the 'scientific' method and the increasing control over our physical environment arising from the greater knowledge of natural phenomena by application of this method. Since scientific method has been applied to the understanding of most aspects of our natural environment there is a variety of vehicles by which instruction in scientific thinking can be carried out. Hence other criteria must be used to determine which of the sciences and which methods of presentation most merit inclusion in school curricula.

Three reasons are then given for the teaching of biology in schools. They are:

1. Although most biological phenomena may eventually be described in physico-chemical terms there is an organisational factor involved which is less obvious in physical systems. Our society is, in one sense, a biological organism hence the study of analogous systems would seem profitable and quite appropriate.

2. Demonstration of the scientific approach is probably more effective through a number of different sciences, since each employs its own variations of the scientific method.

3. Some knowledge of the factual content of biology is needed by all because of its importance to the individual and to the community in such matters as health, hygiene and diet; and by those vocationally interested in agriculture, forestry, medicine, etc.

The paper concludes with the summary quoted in the synopsis.

8. A Plea for the Revival of Technology in Science Courses

Richardson E. (1971), What Price Technology?, ASTJ 17,3, 33-37 (October)

Synopsis

In a well-documented contribution the author discusses the changing role of the scientist-technologist with time, the distinction held between science and technology, the place of applied science in earlier school courses, their absence from the new'pure' science curricula, some of the objections to the new approach, the revival of interest in applications in the U.K. and the introduction in the U.K. and the U.S. of separate courses in technology in schools. The article concludes with an expression of concern that a similar renaissance in interest in applied science and technology has not occurred in Australia.

Discussion

Technology found little place in British school science courses prior to 1918, but from the 1930's until about a decade ago practical applications had been included in Britain, Australia and America. Typical instances were descriptions of the extraction and refining of metals in chemistry and application of principles such as the expansion of bridges in physics.

While the role of the scientist-technologist has become increasingly clear as industry has become more sophisticated, the distinction between science and technology has, however, been still maintained by some. They see science as being concerned with the pursuit of knowledge for its own sake, with applications only being important if they lead to more theory. Others, holding the opposite view, see the relationship between science and technology as being symbiotic or that 'the life and soul of science is its practical application', as Kelvin stated.

The scientists who designed the new (American) school science curricula (of the 1950's-60's) felt that traditional courses overemphasised technological achievement and industrial uses of science. They preferred to develop courses around the more stable attributes of science i.e. the inquiry processes and the conceptual structure of a discipline. Translated into classroom situations this would mean that students were to behave as do scientists in their work. Of the first British projects the Nuffield 'O' level physics is in this vein. Amongst the objections to this 'pure' approach have been that science could be ruined by teaching it as an abstract subject having no practical significance, and that science and technology have always helped each other. A disdain for industry and applied science, an affective by-product of the pure approach, has been noted in Australia and in the U.K.

Both the Nuffield 'O' and 'A' level chemistry curricula have adopted a balanced approach with their inclusion of the pure and the applied sides of the subject. Attempts of another kind are being made in the U.S. and in Britain to balance the theoretical approach to science by the introduction of technology as a separate subject, but this does not satisfy those who assert that science and its applications should be inseparable at the school level.

The author is concerned that a similar revival of interest in applied science and technology has not occurred in Australia to compensate, in part, for the 'pure' approach in many of the courses introduced here recently.

SCIENCE FOR THE CITIZEN, SCIENTIFIC LITERACY

9. *What Science in the Junior Secondary School Should Be*

Doyle, The Rev. J.W. (1959), Is Science for the Masses?, ASTJ, 5,2, 29-30 (August)*

Synopsis

Ability in English expression and the development of interests should be the chief goals sought in the new junior science course in New South Wales. The course should be descriptive, informal, include all the basic sciences and be taught by one person to provide integration.

Discussion

Science during the junior secondary period of four years in the recommended 4-2 Wyndham plan should be largely descriptive, encompass the whole range of the natural sciences and be so taught as to interest children and make them appreciate science. Formal scientific training, for the few who want it, could begin in fifth year.

The chief objects of the elementary 4-year course (in science) should be training in English expression and the development of interests. Pupils should be taught to read and write about science, whereas in the present pre-Wyndham era the 'practical books' required are unprofitable and dispiriting with their trivial experiments. Preferably at the junior level one person should teach all subjects to provide integration.

It seemed a grave disservice to science to attempt to teach its formal aspects to children too young for it. It would be better to leave formal treatment until the fifth year by which time students would have acquired a good groundwork in English and mathematics and be mature enough to grasp quickly matter which at present is so time-consuming and uneconomical.

* One of the contributions to the symposium, entitled 'Is Science for the Masses?' held at the NSWSTA Annual Conference in August 1968. See also Digest 10.

10. *A Knowledge of Material Phenomena is Relevant to Most*

Simmons L.M. (1959), Is Science for the Masses?,*
ASTJ, 5,2, 30-33 (August)

Synopsis

The author chose to deal with the question 'Is Knowledge Dealing with Material Phenomena for the Majority of People?' rather than that of the symposium, conducted by the New South Wales Science Teachers' Association, 'Is Science for the Masses?' The claim is made that topical science, not the 'embalmed fragments of an earlier century .... specific gravities and multiple proportions .... which is served up at school as science, is needed for the majority of people, is desired by them and can be given to them.'

Discussion

Knowledge of material phenomena has great relevance to most people since they are closely concerned with such phenomena throughout their lives. Perhaps the kinds of lecture series for laymen given in the last century at the Royal Institution in London might meet the needs often expressed to the author by adults lamenting the fact that they had no opportunity of learning any science. Lectures like those at the Royal Institution, with their theatrical and illuminating demonstrations, might well be filmed and later televised to reach the widest possible audience.

Instances are given of the interest of first year boys in today's scientific and technological achievements and of non-scientific adults in such topics as the current view of the atom. Treatment of topical science and technology and arousal of healthy interest in the environment can help prevent the present wastage of motivation. This does not involve a lowering of our standards but rather the raising of our standards of presentation and of topic selection.

Apart from the social justice of displaying the present-day science scene to the bulk of people the matter of survival of mankind is now held to lie in the production of more scientists and technologists. If this be true then science must be given to the majority of people, for it is from the culture of the majority that experts are produced.

* See footnote on Digest 9.

11. *Science for the Future Citizen I.*

Thornton J.B. (1959), Science for Citizenship,*
ASTJ, 5,3, 11-16 (November)

Synopsis

The view is taken that the science taught in schools should be tailored to meet the needs of the future citizen of any kind rather than of the future specialists. This science for citizenship ought primarily to be an attempt to communicate what is sometimes called the philosophy of science but preferably called the traditions of the scientific community.

Discussion

Reference is made to the older classics and humanities versus science controversy and to the more recent 'Academic Science' versus General Science clash. Those who have contributed, in the last 40 years or so, to the literature on the General Science movement have taken for granted that science of some kind is to be a compulsory, or nearly compulsory, part of all secondary education. Some strongly favor as the backbone of school science systematic courses in physics and chemistry, distrusting the apparently amorphous nature of General Science. Others strongly favor the General Science approach, perhaps contrasting 'the rich but unsystematic variety of nature itself' with the narrow formalism of conventional physics and chemistry.

During a rather extensive discussion of 'What Does Science Mean?', of 'The Chief Concern of Science', and of 'The Scientific Way of Life' points such as the following are made:

1. scientific theories are expendable and replaceable in a way that scientific habits of thought are not,

2. what is fundamental to science is reliance upon certain methods of inquiry, and

3. only in a derivative sense can we label certain bodies of knowledge as scientific.

* One of the four papers read at the symposium on 'Science for Citizenship' held at the Australian Science Teachers' Association Annual Conference in Sydney, August 1959. See also Digests 12, 13, and 14.

The view of science presented, the author claims, indicates pretty clearly what ought to be at least part of, and perhaps the main part of, science courses for citizens. Even if agreement cannot be reached on the particular scientific facts and laws that should be common knowledge, it must surely be agreed that citizens at large should know what science really is, something of the essence of science, and 'what there is about it that makes it what it is, and makes it go on in the ways it does go on'. It could be said that this implies that courses in General Science ought to be concerned, at least in part, with the philosophy of science; or putting it less pretentiously, the traditions of the scientific community. To illustrate his meaning, the recommendation is made that questions such as 'why do we regard astronomy as a science but hold astrology to be superstition?' should be raised and considered. Another example contrasts the superstitious, irresponsible concept of luck ....of good and bad fortune .... with the scientific notion of probability.

12. *Science for the Future Citizen II.*

Baxter J.P. (1959), Science for Citizenship,
ASTJ, 5,3, 16-18 (November)

Science should be offered to all pupils in school to help them understand the role that it plays in their lives and in the community and how scientists work and think.

Science influences our everyday life in countless ways and also our national policy. The majority of people, however, lack understanding of the scientific forces to which they owe so much. In school science pupils should not be treated as if they were all embryonic scientists. The historical approach will help pupils appreciate the contributions of past and present scientists to industry and commerce as well as to every phase of living. 'It is more important to relate science to our daily lives, such as how a car or a fuse works, or how things grow, than to put acid on zinc and see what happens'.

* See footnote to Digest 11 and also Digests 13 and 14

13. *Science for the Future Citizen III*

Rucks M.W. (1959), Science for Citizenship,*
ASTJ, 5, 3, 18-21 (November).

Synopsis

Science for Citizenship cannot be comprehended by at least 30% of the whole secondary school population. For this group science of the general knowledge type can be incorporated into general studies or social studies courses taken by general teachers. The efforts of science teachers can then be devoted to teaching science to those capable of profiting by it.

Discussion

After quoting the Oxford Dictionary definitions of 'citizen' and of 'science' the author discusses these from the viewpoint of a school teacher. Evidence is then given of the watering down of English, by using short answer questions; of Mathematics, by discarding quantitative work; and of Science, by offering so-called 'B' General Science courses to those having difficulty with the normal courses in these subjects.

From quoted figures giving the annual spending in his State, Western Australia, on betting, on alcohol and on education, the conclusion is drawn that adult citizens' interests are not in education, of which science education is only a part. The problem of the wastage of time of the best science teachers is ventilated, instances being given of the little carry over of school science to everyday life.

Suggestions are made that -

1. those children who show, by intelligence quotient and other testing, that they cannot understand or be interested in the type of discipline required in real science studies, be eliminated from science courses of any kind at as early a level as possible; if necessary 'interest-science' material of the general knowledge type can be incorporated into their general studies or social studies courses; and

2. the teaching and other resources thus made available be used to improve the teaching of scientific principles and the

* See footnote to Digest 11 and also Digests 12 and 14

inculcation of a balanced scientific outlook with the other, more capable pupils.

Adoption of these measures may result in a better distribution of the State's finances and in a greater proportion of young people turning to science teaching, thus easing the teacher shortage situation.

14. *Science for the Future Citizen IV.*

*Travers B.H. (1959), Science for Citizenship**, *ASTJ, 5,3, 22-24 (November)*

Synopsis

Citizens as voters must be taught the proper usages of the knowledge and material advances made recently by science so that they can think for themselves, making their own decisions based on a knowledge of the facts.

Discussion

The key word in the phrase 'Science for Citizenship' is the preposition which in this context must have the meaning 'in order to obtain'. Science has placed the citizen in a paradoxical situation - on the one hand he doesn't have to think, since every material whim is catered for by some mechanical gadget, on the other hand he lives in a world in which science has produced devices and gadgets to overwhelm his personality and his capacity for thought. Added to this dilemma the citizen also has the duty of exercising his vote responsibly, and this he can only do if in possession of the essential facts.

While stating that science for citizenship will be taught by science teachers the author questions whether the science teachers are properly competent to teach both science and citizenship responsibility. Before deciding upon the content of the course, a reassessment needs to be made of whether a pupil can properly be filled with factual knowledge about science before he has the necessary mature judgment to draw valid conclusions from the facts.

The author epitomizes his views on the outcomes of a 'Science for Citizenship' course by stating: 'Clear thinking and ability to observe accurately are more vital and desirable parts of the educa-

* See footnote to Digest 11 and also Digests 12 and 13.

tional process than the acquisition of large amorphous masses of facts, crammed in parrot fashion in order to pass some examination.' Until science teachers answer such questions as: 'Should not science examinations be open-book examinations?', 'At what age should a child first learn science?', and 'What should be the branch of science first learnt?', educational establishments will also fail to teach science as science teachers think it should be taught. Science teachers, however, 'must beware lest science becomes a vested interest' looking solely to itself and also must realize that a man's education is a continuous lifelong process.

15. *Designing a Science-for-all Course.*

Connell W.F. (1963), Science for the Non-Scientists, ASTJ, 9,3, 17-20 (November)*

Synopsis

Attention is drawn to the gulf between Western literary intellectuals and scientists as graphically portrayed by C.P. Snow and then to the more important gap, that between science and the man in the street. The responsibility for bridging this gap lies mainly with the secondary school. The opportunity for doing this is afforded by provision of a four-year science course for all pupils under the Wyndham reorganisation plan. Principles which should be considered in designing this science course are listed. Science teachers have the task of popularising science generally.

Discussion

Discussion is first focussed on the gulf of mutual incomprehension between the literary intellectuals and the physical scientists as publicised by C.P. Snow in his Cambridge lecture on the two cultures in 1959.

The gap arises from the differences in attitudes and interests of the two groups and is being widened by the use of language including the changed meanings of such ordinary English words as 'efflorescence', 'meiosis', and so on. The introduction of symbols and the language of mathematics have contributed to make science beyond the understanding of, and rather frightening for, the layman. It has been suggested that a re-thinking of education is necessary if the gulf between the

*Abstractor's note: This abstract has been prepared not from a transcript of the address by Professor Connell, a humanist, but from the almost verbatim report by Miss E. Renshall.

two cultures is to be bridged.

The more important gap, however, is between science and the man in the street with the critical point being in the secondary education field, now that we are in the era of secondary education for all. At present there are two parallel and inter-related revolutions - that due to the rise of the common man in the 20th century and the technological revolution which affects all aspects of life. Broadly speaking, the task of the school is to develop an understanding of society and the on-going cultural changes.

Science as a contributor to general education has so far been rather neglected but, with four years of general science being given to all as part of the Wyndham reorganisation of secondary education, there is now the opportunity to remedy this neglect. Several principles which should be considered in designing such a science-for-all course are then stated. Those concerned with content and its organisation, in abbreviated form and in the sequence as given, follow:

1. The pupils should learn that science is a number of conceptual schemes, ideas and theories.

2. The unity of science should be revealed, demonstrating the manner in which one science illuminates another.

3. The course should not consist of separate subjects but of a series of appropriate topics dealing with modern rather than classical science.

4. There is a need for some topics to be studied in depth to provide a basis for work in more advanced fields.

5. Science being an activity, according to Conant, brings the necessity to have two ingredients stressed:

   (a) practical work in field and laboratory, and

   (b) the applications of science in the modern world.

6. The course should examine the lives and contributions of modern scientists and thus provide a basis for science and scientists to become comprehensible and for bridging the two-cultures gap.

In addition to their responsibility in the schools, science teachers have the further task of popularising science, of building understanding and interest among the general public who are non-scientists.

16. *Proposals to Increase Scientific Literacy.*

Mason P. (1971), Speaking Scientific, ASTJ, 17,3, 39-42 (October)

Synopsis

If the primary concern of school science teaching is widespread literacy in science then two proposals are made. The first, calling for immediate action, is that steps be taken to ensure that pupils have sufficient numerical skills to save them from being overwhelmed by the massive statistics confronting them. The second is a suggestion that the senior science program of the 1990's might consist of three parallel streams: the physical scientists' view of the universe and of matter, human biology and technology.

Discussion

Appreciation of the influence of science, now a matter of life or death for our civilization, is very dependent on understanding something of the scientific language in which the ideas of science and technology are expressed. For most Australian schoolchildren in the 1970's, ability to speak 'Scientific' is more important than ability to speak French.

Assuming that our primary concern is the science education of the future citizen, then our bias will be toward those aspects of science closely related to the joys and sufferings of mankind. Part of the challenge is to show how Newton's Laws of Motion, the Periodic Table, and the breeding of sweet peas help in any way in dealing with contraception, drugs, pollution, conservation, etc.

Agreement as to the reasonable minimum of scientific knowledge and ability is difficult to obtain. Pleading by professional scientists for the inclusion of particular topics is to be resisted. An entire curriculum cannot be changed overnight; however, a suggestion is made for immediate action and, later on, one for a generation hence.

The immediate action proposal arises because society is becoming increasingly technological and, also, increasingly quantitative. Hence pupils should have sufficient skill and familiarity with numbers to prevent them being overwhelmed or intimidated by the massive statistics confronting them. An example using simple facts, but really no scientific knowledge, is given showing how one may calculate that, unchecked, in under 400 years each person would have about one square yard of the earth's land surface apiece. The concept of exponential change might mean more in such examples of population growth than in examples drawn from radioactive decay. A rather homely example involving Avogadro's number is also given.

A senior science program a generation hence might be derived from a proposal by Professor Phippard of Cambridge that two-thirds of the two years' work in a general university science course should consist of three main, parallel streams:

1. the physical scientists'view of the universe and matter (including also some biology and psychology);

2. human biology, more typical of experimental science than the usual approach via physics; and

3. technology, including computing, and its influence on attitudes to living.

Phippard, while agreeing with those who regard the program as suitable more for the schools, maintains that only after the universities use it to prepare teachers with the required breadth of training and approach can it be transferred to the schools.

THE SCIENCE PROGRAM AND ITS ORGANISATION

17. A Suggested Primary-Senior Secondary Science Program.

Stanhope Roy W. (1958), Modernising the School Science Program, ASTJ, 4,3,44 (November)

Synopsis

A recommended program of science from the primary school through to the senior secondary school is outlined.

Discussion

This contribution is largely a condensation of the paper 'Physical Science and Biology Should Replace Other Junior Secondary School Sciences' read at the Adelaide Congress of ANZAAS, 25 August 1958 and published in ASTJ, 5,1, 47-53 (May 1959) - see Digest No 20.

Mention is made that responsible committees enquiring recently into secondary education in most English-speaking countries have recommended that all junior secondary school pupils should take an integrated 'General Science' course.

The principal objections to the teaching of general science are then listed. Most of these criticisms would be met if two separate courses: Physical Science and General Biology replaced the General Science course, both to be required of all pupils and each given the time allocation of a single subject.

A satisfactory overall program would then be:

Primary School

True Elementary Science, not just Nature Study

Junior Secondary School

Physical Science and General Biology

Senior Secondary School

General Students

Advanced Physical Science and/or Advanced Biology

Intending Specialists

Courses in the separate sciences.

18. *Junior Science Should be General Science*

Anders D.J. (1959), The Necessity for General Science, ASTJ, 5,1, 63-66 (May)*

Synopsis

The varied objectives of the schools viz. to commence the training of scientific manpower, to prepare children for citizenship in a technological society and to facilitate the physiological and psychological changes that occur in early adolescence can best be attained through the teaching of General Science.

Discussion

Accepting the original and apt definition of General Science as being 'a course of scientific study and investigation which has its roots in the common experiences of children and does not exclude any of the special sciences', two reasons for its teaching follow. First, as research has shown, children are interested in and wish to know more about their total environment. Second, General Science does not exclude the information provided by, nor the methods of, any of the 'separate' fundamental sciences. Examples are given of instances in which General Science caters for both of these. It is pointed out that the author does not regard General Science as a means of introducing biology into the curriculum - this is incidentally, but not deliberately, true.

* One of the three papers read at the symposium on 'General Science or the Separate Sciences in the Junior Secondary School?' held at the ANZAAS Congress in Adelaide, August 1958. See Digests 19 and 20 for the other papers.

Two reasons are given why General Science is <u>not</u> generally taught in schools. The first is the fear that examination results (in the separate sciences) at a later stage may be adversely affected - but no evidence has been forthcoming that this is the case in South Australia. The second reason is that there is a shortage of suitably trained teachers, especially biology teachers. There is room at this university (Adelaide), as there now exists in Melbourne and Sydney, for another kind of science degree more broadly based and tapering to a narrower summit than traditional degree programs.

Tersely put, General Science is necessary because it (alone of the various alternatives) meets the needs of society and the interests of children.

19. *The Separate Sciences Should be Available at the Junior Level*

Keeves J.P. (1959), The Case Against General Science, ASTJ, 5,2, 35-41 (August)*

Synopsis

The two fundamental assumptions apparently underlying all claims in favor of General Science are (i) that all boys and girls should learn the same things in the same way, and (ii) that there is a certain rather large body of knowledge that should be acquired by everyone. Not prepared to accept these assumptions, the author believes firmly that with the rapid increase in the number and kinds of secondary school pupils, many attending for only two or three years, a variety of science courses should be offered -- those which cater for the average pupils and those, in the separate sciences, for the abler pupils who will be the future scientists. One type of course, General Science, or even compromise courses such as Physical Science and Biology can never fulfil the wide range of needs nor can specialist courses in Physics and Chemistry.

Discussion

The General Science movement began in England in the 1920's, mainly to remedy two defects - the too-academic treatment of Physics and Chemistry, and the absence of Biology from the offerings in boys'

* See footnote to Digest 18, and Digest 20.

schools. Influenced largely by the Science Masters' Association's reports of 1936 and 1938, General Science became an Intermediate Certificate subject in South Australia in 1944. Initially receiving some degree of acceptance, its popularity has declined in both places generally except in the English secondary modern schools which are largely free to develop courses suited to the needs and requirements of their pupils.

The enrolment in the South Australian State secondary schools has markedly increased in recent years, but most of the increase has been of average and below average ability pupils. Most of these latter continue in school for only 2 or 3 years; they cannot cope with the traditional courses in Physics and Chemistry, and General Science seems the obvious answer for them.

Difficulties have been experienced in attempts to break down the barriers between the separate sciences and hence to display the unity of science, the chief of the reasons for the creation of General Science as a subject. It is suggested that perhaps the only effective way of avoiding subject divisions is to follow across the different branches of science topics such as 'The Air Around Us' but for reasons given the topical approach can never be completely satisfactory. Differences in their needs and interests exist amongst boys, amongst girls, and between the sexes. Hence it is not advisable that all pupils should take the same course in General Science over a period of years.

The slow growth of General Science in the schools, and indeed its partial relative decline, may be due to the problem of finding teachers qualified and happy to teach it, particularly the biology sections. Discussion is next centred on such other difficulties in the teaching of General Science as the absence of laboratories adequately equipped to handle all aspects of the subject; the allocation of the most-junior, least-qualified staff to General Science classes; and the poor foundation it provides for matriculation courses in Chemistry and Physics.

While excessive specialisation is to be guarded against, it is asserted that training in accuracy of thought and of expression, in the use of figures and in the exactitude of a scientific experiment can only come for the able boy if he studies some subjects in depth. Narrowness and broadness are attitudes of mind that result from the way in which a subject is studied rather than from the content of the course. Courses must be kept free from overcrowding so that the teacher has ample time to discuss the subject with the pupils.

The traditional divisions between subjects are best removed, not by trying to stress an artificial unity in the early stages, but by trying to show the connections and relationships at a stage, near the end of a boy's schooling, when these can be understood. Schools must be left free to offer a variety of science courses each geared to the needs and interests of different groups of students - the specialist sciences for the more able and General Science for the others.

20. *Physical Science and Biology as the Only Junior Sciences.*

Stanhope Roy W. (1959), Physical Science and Biology Should Replace Other Junior Secondary School Science Courses, ASTJ, 5,1, 47-53 (May)*

Synopsis

The junior secondary school sciences offered in each of the Australian States, the chief criticisms of present General Science courses and the difficulties encountered in implementing the latter courses are first stated. Then the recommendation is made that if two separate courses, Physical Science and Biology, were to replace General Science, these criticisms would largely be met and the difficulties overcome.

Discussion

Reference is made to the fact that the committees set up in recent years, English-speaking at least, to report upon desirable reforms in secondary education have recommended that some kind of general science course, drawing its subject matter from the basic sciences, be required of all junior pupils. This was the case in the most recent of these reports, that of the Wyndham Committee in New South Wales. This committee used the term 'Science' because of the widespread dissatisfaction with existing 'General Science' courses and recorded its appreciation of the great difficulty in constructing a suitable generalised science course.

The junior secondary science offerings in each of the Australian States are next listed, followed by the chief criticisms of current General Science courses viz. their lack of unity, their superficiality and the difficulty in setting suitable examination papers. Next Eric Ashby's trenchant criticisms made in 1946 of Australian school science teaching in general, and of General Science in particular, are mentioned and his belief that the two all-important needs of secondary school pupils were an understanding of the contemporary scene and power to use the scientific method. Instead of General Science or the

* See footnote to Digest 18, and Digest 19

separate sciences at junior levels, Ashby recommended two courses:

1. the history of empirical science and technology leading into the history of scientific ideas, with the whole embedded in its social context, and

2. a course in scientific attitude in which the powers of observation, classification, induction would be trained.

This section concludes with the author's (Stanhope') criticisms of Ashby's suggested courses.

In addition to the defects in present-day General Science teaching already mentioned, two other serious problems exist. These are the shortage of graduate science teachers generally, and of those with tertiary qualifications in both the physical and the biological sciences in particular; and the difficulty of providing within a single room adequate facilities for handling all the component sciences in a general science course.

All these problems would be largely, if not entirely, overcome if:

1. Physical Science and Biology were to replace all other sciences, in junior secondary schools,

2. both courses were required of all pupils, and

3. if each were given the same time-allocation as any single major subject in the curriculum.

21. *Criticisms of Integrated Science Courses*

Prince J.R. (1967), The Integrated Science Course - A Pipe Dream?, ASTJ, 13,2 11-17 (August)

Synopsis

The purpose of this paper, states the author, is to raise questions about assumptions apparently accepted too readily. The word integration does not seem to apply correctly to most contemporary Australian school science courses. Two things are questionable: is integration in any true sense possible at this level? and does the composite nature of the so-called 'integrated' courses achieve a better learning situation than the traditional approach in separate disciplines? Real integration rests with the teacher presenting the course and will be achieved only insofar as he appreciates the essential unity of science. Integrated planning between the four sciences is desirable and even essential, but beyond this the practicability and the desirability of introducing composite general science courses need serious re-examination.

Discussion

It could be argued that real appreciation of the outlook and principles of science may be inculcated more by the study of one discipline in depth than by a broad but superficial ranging over a wide field. The most desirable foundation for this study in depth of a specialism, say most contemporary science educators, is an initial acquaintance with the major scientific disciplines - physics, chemistry, biology and geology. But how is this desirable goal to be achieved?

The current trend is for all four to be included in an 'integrated' science course, 'integrated' because the four subjects are taught concurrently by the one teacher from the one textbook. That better results will be achieved by such teaching does not seem, so far, to have been justified from theoretical considerations or practical results. The different meanings attached to 'integration' further confuse the issue.

Integrated Planning of Courses

The first sense in which the term 'integration' may be applied to a science course is that of integrating the planning. By this is meant that courses in the separate sciences should be so planned as to obviate the wastefulness and confusion where the same or similar overlapping areas have in the past been treated from quite different standpoints and with different terminologies. Opportunities for mutual reinforcement should be taken and the strong elements in common between the disciplines allowed to emerge. It has been argued that this is as far as integration should go and that such integrated planning of the separate sciences would remove most of the faults in the old system.

'Integrated or Composite'

It is not self-evident that greater real integration is realised by converting the separate disciplines into a composite course, the term 'composite' being preferable to denote a science course taught as one subject, probably by one teacher out of one textbook. The present Australian trend seems to be more towards composite than towards integrated courses. The claim that some courses are integrated is open to question. 'Integration', in a Western Australian course insofar as it is achieved at all, is restricted to bringing together at an initial level ideas from the four main disciplines in certain topics, e.g. the atmosphere, the earth, and so on. After this kind of initial treatment, structures based on the traditional disciplines take over. The so-called 'integrated' textbook based on the 'integrated' science course in New South Wales consists of chapters each devoted almost exclusively to material from only one of traditional disciplines. Both courses are, by the author's definition, composite courses.

These two examples, of a number, lead to the question as to whether the integration sought is either practicable or desirable. Some degree of separation of the disciplines is inevitable since each treats a particular area of knowledge, has its own set of techniques and develops its own vocabulary.

A Basis for Integration

It seems that a school course in physics and chemistry could be substantially integrated beginning with the atomic ideas of matter. But if this integration is possible, it is doubtful whether integration of either of the two with biology and geology, or of biology and geology at the school level is possible at all. While links can be established, and often are, between the separate disciplines, true integration is achieved through such subjects as biochemistry, geophysics, ecology etc. These are generally accepted as being suitable subjects for second and higher years of university study but, for a number of reasons, they are hardly suited for school presentation.

It could be said that a simpler integration is available by considering the areas where the separate sciences impinge upon one another, e.g. the soil, the atmosphere, and so on. While such an approach may give the student some sense of unity between the disciplines, further pursuit of the science of the soil involves following the logical path of a traditional discipline. The typical composite course tends to lose the advantage of structured sequential development, so much so that some students have stated that they cannot follow science because 'it seemed to jump around so'. For a course to be satisfactory to the teacher or the learner, a structure of some kind is essential. It has been suggested that the major common scientific concepts such as matter, energy and the like are better structural units than the traditional disciplines. This may be so but it has yet to be demonstrated.

Other matters discussed in the paper include problems associated with the teaching of composite courses by one teacher or by a team, arising from the 'continuous and growing rapid expansion in the sheer volume of scientific knowledge', and that while the average and below average pupil may find interest in the wide range of descriptive work in a composite course such a course is unsuited to the highly gifted child. The final point taken is that in the present composite courses, the vitally important integration between physics and mathematics and between chemistry and mathematics is being largely abandoned. The suggestion is made that the physical sciences and mathematics should be integrated and that of statistical mathematics with the other sciences is worth attempting.

22. *Integration of Science with Other Subjects*

Bishop M. (1963), Science in Future, ASTJ, 9,3, 23-29 (November)

Science in future will not only be integrated within itself but with other subjects. Integration of science in syllabus preparation, in teaching and in textbook writing has proved difficult. The view of some that science just cannot be integrated is not accepted, reasons being given for taking the opposite stand. Integration of any learning is something to be accomplished by the learner, not by his teacher, but ways of making it easier for the pupil are suggested. The hope is expressed that science teachers of the future will 'reach out' towards all aspects of learning.

Discussion

School science in future will not only be integrated science but will be closely interwoven with English, History, Language and Mathematics because science touches upon, depends upon and helps facilitate, an understanding of them all. Science will be accepted in education because it contributes to, and is part of, our culture.

Difficulties have been experienced by some in preparing an integrated science syllabus, in teaching in an integrated way, and even in writing an integrated textbook. Many will assert that these difficulties were to be expected because science just cannot be integrated. Explanations are given as to why the author is not prepared to accept this view.

Graduate science teachers who have in their degree programs specialised in one or two sciences, and particularly those who have not availed themselves of opportunities to keep their subject matter up-to-date, would have difficulty in teaching an integrated course. They would also have difficulty in suggesting the material from other disciplines, and even from their own, which should be included in such a course. Another reason is that while university staffs readily provice assistance for the ill-informed teacher, such help fails to some extent because the staff members lack school teaching experience. These situations are not of themselves reasons for not attempting to integrate the sciences, nor that it is impossible, but they are warnings that integration will not be achieved easily.

It should not be forgotten that 'integration of any learning is a personal process to be accomplished by the learner, not by his teacher.'

However, teachers may make integration easier for the pupil, several ways being suggested. Eventually there will develop a number of integrated science courses each written by a specialist in one or two sciences who has 'worked-up' the other sciences. That one teacher working on his own could do better than this in less than five to ten years is most unlikely. Hence a team of writers and teachers might accelerate the process without too great harm to the unity of the subject. This has been accomplished in New South Wales recently, but American experience with such team writing has shown that the refining and maturing processes originating in classroom practice take from five to ten years.

About one-third of the paper is then devoted to a discussion of science and English, particularly to problems in the communication and the reception of ideas and information and to the mutual benefits to be gained by linking science and other subjects through the use in lessons on other subjects of writings by scientists and vice versa.

23. *Science - Separate or Integrated With Other Subjects*

Shepherd S.R. (1973), Science in the Curriculum, ASTJ, 19,2, 89-94 (June) and 19,4,98 (December)

Synopsis

A representative of each of the six State Science Teachers' Associations was asked whether science had a special contribution to make to the education of children; if so, what it was; and if science should exist as a separate subject in the curriculum.

No clear cut consensus could be discerned in the opinions expressed, due chiefly to the different meanings attached to 'science' and to 'integration' and to the qualifications accompanying some statements. On the matter of whether science should be integrated with other subjects or not, the responses seem to be:

New South Wales	-	integrated
Victoria	-	a separate subject
Tasmania	-	integrated only at the junior level
Queensland	-	interrelated with other subjects
Western Australia	-	integration unlikely in near future, probable in a possible senior course
South Australia	-	separate, if the junior curriculum development begins with subject selection; integrated, if development begins with the desirable outcomes of the total curriculum.

Discussion

New South Wales (Jean Stock)

Science as 'exploration' or process can and does take place in lessons in other subjects. So, unless science is considered solely in terms of content, its traditional separate place in the curriculum is artificial. We should be moving deliberately towards a blurring and eventual elimination of the knowledge - compartmentalising subject boundaries.

The aims of secondary education should be considered in exploring alternative forms of curriculum organisation. The Education Department has suggested that the basic needs of the individual student and of his society are relevant in selecting curriculum content. To the student his world is complex and interdisciplinary. Current thinking about the place of science in the curriculum for Grades 7 to 10 suggests an emphasis on aims contributing to the development of the student. Thus content areas traditionally associated with social science, geography and health education have been included.

A two-day conference with members of other subject organisations is being planned by STANSW for later this year.

Victoria (K. Creed)

Creed is most emphatic in his denunciation of the cult towards 'generalism'. Instead of recognising the unique characteristics of subject disciplines, we look for characteristics in common and finish up with General Studies. In our efforts to combine everything, we end up with nothing. Some topics, e.g. Housing, lend themselves to a treatment in which science can be truly integrated. But this is not the common situation, because science IS DIFFERENT. It has its own viewpoint, special rooms and services, and unique equipment - all implying specialist teachers trained to use this hardware effectively.

The subject matter and techniques make science really different. Science is where the ACTION is; we look for evidence, test hypotheses and reach conclusions based on our discoveries. Conservation and consumer protection are cited as examples of the active scientific approach, not of empty emotive phrases.

General Studies and Environmental Studies represent the two main moves in the last five years to relate subjects to each other. Some schools have left science out of General Studies, or have included it, but as a separate unit. Some themes, e.g. Housing, Communication, Animals, allow meaningful integration. Environmental Studies is really just science with a particular emphasis and some effective integration with geography. ASEP, with its social science bias, will provide further variety of approach.

STAV is represented on the Joint Council of Subject Associations, set up in 1966, which through the conferences and meetings it organises, hopes to promote common philosophical aims and to coordinate educational improvement efforts.

Tasmania (G. Fish)

Science, in primary and early secondary school, means to Fish a child-centred exploration of the natural environment which, by its very nature, can contribute to the intellectual, social and emotional development of children. Science, then, no longer needs justification because f the importance of its content. There should be a more gradual trans: .ion from the child-centred experience to the content-oriented experience of the upper secondary school. Even at the latter level science courses should be investigative and relevant to the student's needs in his natural environment.

Despite the uniqueness of science, there is great scope for integration with materials from other disciplines. The new syllabuses in science and other subjects have complementary objectives, broadly conceived in terms of child development. At the primary and lower secondary levels a child-centred exploration of the environment involves experiences other than those compartmentalised into science. Examples are given of topics involving integration, e.g. pollution studies, cosmetic science, models and toys.

Queensland (R. Jones)

No subject should exist in isolation. Today, more than ever, the studies of science, of geography and of the social sciences are very much interrelated. In our particular school sciences, the student needs background knowledge of mathematics, e.g. in quantitative problems. In teaching industrial processes the social sciences become involved when air, water and noise pollution demand attention.

There is room, however, in the overall curriculum for science because of its unique contributions, e.g. it is one of the few subjects where real discovery can occur. Science no longer is restricted to physics and chemistry. Just as the base of our science courses has broadened, so too must we depend more and more on interdisciplinary help in conveying meaningful and useful material.

A joint council of subject associations has been formed to further mutual concerns.

South Australia (L.D. Russell)

To integrate or not to integrate science with other subjects depends on the basis used in building a junior secondary curriculum. If subject selection comes first, followed by consideration within the separate subjects of the possible outcomes of each, then science should be retained as a separate subject. Some discussion follows of the doubtful benefits of integration within a subject-centred curriculum. Separate subjects rigidly restrict the total educational program if developed in isolation or in a general studies course in which each established subject has its fair share.

If the desirable outcome of the total junior secondary curriculum is the starting point in its development, the need for separate subjects might well disappear. This is a point in the rationale behind the new open-space schools in the State. Different attempts at topic integration have been made. Probably the most effective 'integration' occurs in field studies and camps in which subject specialists combine to provide comprehensive study programs.

Western Australia (J.R. McIlwraith)

The major difficulty (if science is to be separated in the curriculum) is the timing for the switch from general science (integrated into the general curriculum or not) to specialisation. The most serious problem is provision for those students whose science education terminates at school. If integration can supply a satisfactory solution, it will have many supporters in this State.

In the primary school the time saved with the introduction of metrication could be used to introduce additional science into an integrated syllabus. Beyond the primary, McIlwraith feels that integration can be best achieved by adopting some form of multiple option course - but what it entails is not stated.

A major curriculum project in junior secondary science has just been completed. It seems unlikely that any serious attempts to integrate (science with other subjects??) will occur in the near future. There may be in the near future a senior non-matriculation course involving integration of science with related subject areas.

ON CURRENT COURSES IN GENERAL AT BOTH LEVELS

24. Present Science Courses in Australian Schools

Stanhope, Roy W. (1961), Science Courses in Australian Schools, ASTJ, 7,3, 23-29 (November)

Under the major headings 'Junior Secondary School Courses', 'Secondary School Chemistry', 'Secondary School Physics', and 'Secondary School Biology", the following information regarding each of the six States is provided:

1. the titles of the different courses offered or about to be offered,
2. an indication of recent or approaching changes in the content of a number of these courses, and
3. recent innovations in public examinations on some of the courses.

A table shows for each State the science courses categorised as General Science type or separate sciences offered in each school year, and the point of incidence of the public examinations.

The 'General Trends Affecting Science Education' were identified as being:

1. extension of the period of secondary education and alteration of its content and methods to provide a better general education for the great majority of students and, through electives and the extra year in some States, a more challenging specialist education for the talented majority;
2. extension of the teenagers' contacts with science to all its branches;
3. modernisation of science courses so that twentieth century, not nineteenth or even eighteenth century, science is being presented, and
4. greater use of short-answer examination questions, including types which involve more than recognition or recall of factual information.

25. *Remedying Some Failings in Science Teaching*

Carswell D.J. (1958), Science Teaching - Where Does It Fail?, <u>*ASTJ*</u>*, 4,3, 47-49 (November)*

Synopsis

If science is to be taught successfully, interest must be aroused not destroyed. More emphasis should be placed on understanding and less on learning.

Discussion

To arouse and sustain interest in science:

1. science teachers themselves must be interested - or, better still, enthusiastic about their subject,

2. better material facilities should be provided and laboratory assistants employed,

3. more academically-qualified teachers need to be attracted by offering better conditions and higher, more competitive salaries, and

4. science needs to be taught as something to be understood and to reason about, not merely as a jumble of facts to be swallowed.

A completely new syllabus appears to be needed, one which has its basis in generalities and fundamentals with the inclusion of more general topics that imply the understanding of various principles. Inclusion of such topical subjects as rocket propulsion, space travel and atomic power would interest and motivate students to understand the principles on which they are based. Such an approach would be in marked contrast with the present system of learning facts, formulae and principles as necessary for "some obscure, distant and seemingly hypothetical reason". Science affords one example where project and pupil assessments rather than examinations would benefit the purposes for which the subject is taught.

26. *Some Desirable Changes in Current Science Teaching*

Jones A.W. (1958), Impressions of Science and Mathematics in Schools in the U.S.A., ASTJ, 4,3, 60-64 (November)

Synopsis

Warnings are given against the excessive concentration found in Australian science teaching on fundamental principles on the one hand and against the superficiality found with the early years in the U.S.A. on the other.

Discussion

Examples are given of the over-concentration on principles to the neglect of simple practical applications and modern developments in Australian teaching. Considerable time is given in physics courses to the working of all kinds of problems on Ohm's Law but none on learning how to replace a fuse or to detect a break in a circuit. Again, an inordinate amount of time is spent in successive junior years, and sometimes beyond, in repeating work on specific gravity and density. Justification is sought for our precise, quantitative and lengthy treatment of specific and latent heats when it is remembered that some of our students cease the study of history and geography in the first (this is queried by the abstractor) secondary school year. Criticism is also made of the fact that (in South Australia) the whole field of electronics is barely touched in the highest, Leaving Honours, year.

The question is asked: 'Should the science courses be reviewed to see if there is any 'junk' that can be discarded?' Since science teachers are those most loath to discard material whose value they have not questioned, the presence of a non-scientist on review committees is recommended.

27. *Who Decides What Students Should Learn in Each State?*
Shepherd S.R. (Ed.) (1971), Who Decides What Students Should Learn?, ASTJ, 17,3, 81-91 (October)

This paper, sub-titled 'An Outline of the Processes of Science Curriculum Development for Australian Schools' comprises information relevant to each of the six States supplied by a representative of the State's Science Teachers' Association and a summary prepared by Shepherd.

Synopsis

Although the processes of curriculum development differ from one State to another, some generally applicable statements may be made.

At the senior secondary level in each State approval of subject syllabuses and the conduct of the public examinations leading to university entrance are the responsibility of a statutory body representative of the universities (most strongly), of other tertiary institutions, of the State Education Department, and of public and independent schools. Half the science courses are adoptions or modifications of the biology, chemistry or physics materials developed recently in the U.S., the others are determined by detailed syllabuses prepared by special subject committees of the responsible board.

At the junior secondary level in some States this same body, in others a separate body with strong teacher representation, exercises mainly an advisory function in curricula matters. More scope exists for teacher initiative at this level. Most external examinations and their accompanying prescribed syllabuses have gone. Suggested content for general science courses are available but schools have increasing opportunities to develop their own courses or to select from available published materials, Australian and overseas in origin. Work is under way in most States to produce further science materials to assist students and teachers.

Science Teachers' Associations provide opportunities to discuss existing courses and disseminate new ideas to encourage curriculum innovation in schools.

Discussion

Significant matters not common to all or most of the States have been extracted from the separate State reports.

New South Wales (C.L. Macdonald)

'Notes on the Syllabus', elaborating on the depth of treatment of, and suggesting a possible teaching time for each topic accompany the syllabuses at both levels. The junior committee is engaged in a number of activities including:

1. syllabus revision based on teacher feedback,
2. writing behavioural objectives for the syllabus, and
3. investigating the relationship between primary and

secondary science.

Trials of new senior syllabuses in multi-strand science (double subject), physics, chemistry, biology and geology .... in close association with American materials .... are being conducted in some schools over 1971-72 with the assistance of two full-time curriculum officers. -

Australian Capital Territory (Sister A. Cunliffe)

The A.C.T. is still linked with New South Wales in curricula and public examinations but the establishment of a separate education system is a future possibility.

Victoria (W.C.S. McCullagh)

A great diversity in junior secondary science curricula exists since in the government secondary and the independent schools each school staff decides the entire curriculum for the first four years. At one end of the curriculum spectrum science is incorporated into General Studies, while at the other end, some schools still teach to the formerly prescribed syllabus. In between these extremes other schools are using British and American materials or their own curriculum units. A Standing Science Committee has produced a suggested syllabus for Forms 3 and 4 and three curriculum units and it is preparing for teacher use a synopsis of available curriculum materials.

At the fifth form (Leaving) level, schools have the following alternatives:

1. to present their students for the public examinations based on prescribed syllabuses, or

2. to determine their own curriculum and issue their own certificates, or

3. to modify their curriculum within the subject boundaries and conduct their own examinations, or

4. to introduce, after approval, courses in subjects, e.g. Environmental Studies, General Science, outside those offered by statutory board.

With the increasing role of teachers as curriculum innovators, there seems to be needed in Victoria, if not in Australia, a permanent curriculum body providing a large range of materials to assist teachers in organising their own curricula.

Tasmania (R.B. Brown)

Junior science (Forms 1 to 4) syllabuses are outlines of end-points to be reached, not subject topics prescribed in detail. A feature of a new lower secondary general science syllabus under preparation is the emphasis on themes with applications in all branches of science.

At the senior level, CHEM Study and the 'Web of Life' have been adopted, while new syllabuses, not adoptions of overseas materials, are being proposed for physics and geology, with that for the latter aimed at major concepts and principles and man's role in shaping his environment.

The close cooperation between syllabus committees and the Science Teachers' Association is evidenced by such actions as the referral of proposed syllabuses to the Association before final decisions are made.

Western Australia (H.A. Pearson)

At the junior secondary level (Forms 1 to 3), an achievement certificate scheme is being introduced. Under it any school can use its own science course but for Board recognition approval of the objectives, content and assessment procedures is necesssry. The science courses followed by most schools have been developed after classroom trials from the previous Science A and Science B courses, with emphasis on the major ideas.

Operating on an experimental basis in a few schools are IPS and ISCS courses for juniors and Human Biology as a non-matriculation subject for seniors. In preparation for a course called 'TPS - The Process Way to Science', based on the AAAS curriculum 'Science - A Process Approach', four pupil-based workbooks are undergoing trials.

Queensland (G.W. Dettrick)

Quite extensive modifications to the previous processes of curriculum development may follow implementation of the recommendations of the Radford report of 1970. A Subject Advisory Committee for Science, with majority teacher-representation, will recommend junior and senior syllabuses which will 'present a broad framework of the subject and not prescribe its detail'. Internal school assessment, with Board and Moderation Committee control, will replace the Junior Public Examination after 1971 and the Senior after 1972.

New subjects, outside those recommended by the Committee, may be initiated by schools, subject associations and other interested bodies. Most schools will continue to use the present syllabuses while awaiting the Committee's recommendations; other schools are experimenting with overseas materials, JSSP units, or their own curricula.

South Australia (R. Sumner)

If the Secondary School Science Curriculum Committee, having jurisdiction over junior levels, decides that a new course is needed, pilot materials are trialled in a few schools, modified after feedback and then introduced in all schools.

See also Digest 28.

28. *School and Teacher Curriculum Autonomy in the States*

Buchan A.J., et al (1971), Curriculum Autonomy: How Much Do You Have? ASTJ, 17,3, 15-18 (October) and 17,4,30 (December)

In July 1971, the editor of the journal requested of the Director of Secondary Education in each Australian State a brief official statement about the extent of curriculum autonomy permitted science teachers at both junior and senior levels. From the statements published verbatim in the journal, the following digests were made:

Junior Secondary School Science - Synopsis

The overall situation is the marked degree of curriculum autonomy given in recent years to schools and teachers. Syllabuses and other curriculum documents are prepared by committees, on which teachers have majority representation, for approval by statutory boards. If the States are listed in decreasing order of the autonomy presently given to schools and/or teachers, then it seems that South Australia, Victoria and Tasmania are roughly together in first place, followed by Western Australia, then New South Wales, and finally Queensland (but see later entry under this State's name).

Discussion

South Australia (K.E. Barter)

A wide range of topics are offered in a number of syllabuses.

Complete autonomy given teachers to select topics from or outside the syllabuses.

Victoria (A.E. Schruhm)

For Forms III and IV in the Secondary Division is available a suggested list of topics designed to follow on from the JSSP units produced for Forms I and II.

Each school science faculty is free to devise its own courses, subject only to approval by the school principal.

For Technical Schools guide syllabuses and supplementary information are issued.

Schools are free to develop their own courses for Forms IV (Intermediate) and V (Leaving) but most follow the prescribed syllabuses set for these public examinations.

Tasmania (C.D. Brown)

An official document lists the aims and then expands them in short statements.

Teachers have virtual autonomy in planning courses which will encompass the stated aims.

Western Australia (D. Mossenson)

For recognition of a course for Achievement Certificate purposes, the objectives, a summary of content, and methods of assessment must be approved by the Board's Science Advisory Committee. Two courses meeting these requirements are running in departmental schools, with one of the courses being the ISCS in two schools.

Freedom is granted teachers to vary courses within the Board's general framework, except that in departmental schools approval by a superintendent of science is required.

New South Wales (A.J. Buchan)

Principles, understanding, and content in broad terms are stated in the syllabus.

Teachers are free to determine content and teaching methods of relevance to the pupils and which will enable the aims to be achieved.

Queensland (Source - Memo to Principals of High Schools)

The existing prescribed syllabuses will remain, pending consideration of the Radford committee's proposals for the abolition of the Junior examination and for other changes; new syllabuses are to be prepared but dramatic changes are unlikely.

It is envisaged that teachers will be given increased freedom in interpreting the syllabus.

Senior Secondary School Science - Synopsis

At this level, contrary to that at the Junior, curriculum autonomy for schools and teachers is non-existent as far as content is concerned except for minor instances mentioned later. The lack of freedom is due to the fact that matriculation (university entrance) is determined by a student's results in the public external examinations held at the close of secondary schooling. The subject matter for these examinations, uniform within each State, is determined by prescribed syllabuses or curriculum materials such as CHEM Study, PSSC, and 'The Web of Life'. These syllabuses or materials are prepared or recommended by committees usually dominated by university representatives and then approved by the statutory board responsible for the conduct of the examinations.

Discussion

The only instances where some degree of curriculum autonomy is given schools are found in three States.

Victoria (A.E. Schruhm)

In secondary schools which conduct their own examinations at the Form V (Leaving) level, each school faculty is free to determine its own science curricula.

Western Australia (D. Mossenson)

In two courses examinable material should be taught for only part of the time. In 'Web of Life' biology, about three weeks are 'free' for the study of topics especially appropriate to the school. In Human Biology about 40% of the final external assessment is awarded in any way the school wishes - most often for individual investigations chosen by the school or student but relevant to the course.

South Australia (K.E. Barter)

For courses developed and certified by the Education Department, as distinct from the prescribed syllabuses of the Public Examinations Board, the syllabus committees suggest a range of topics, which is less than that offered at the Junior level.

Teachers have freedom to select topics.

See also Digest 27.

29. *Some Aspects of School Sciences Found Hard by Students*

Richardson E. and Stanhope R.W. (1971), Why Do Some Secondary School Pupils Find Science Hard?, ASTJ, 17,3, 66-74 (October)

Synopsis

The most 'popular' reasons given by a large number of Sydney pupils, drawn from all six forms, for finding science 'hard' were: its complicated nature, over-full syllabuses, lack of interest in science, its irrelevance to life and future career, and the inclusion of too many branches of science. Analyses of the responses from junior and senior pupils are reported separately.

Discussion

Prompted chiefly by criticisms that the senior composite science courses in New South Wales were overloaded with content and that some of the content was too sophisticated for the pupils, an attempt was made to ascertain the opinions of the consumers about their courses. Some 1700 pupils enrolled in Forms I to VI in five Sydney schools gave spontaneous open-ended answers to the questions:

1. Do you find science easy or hard?

2. Give the reasons for your answer.

Analyses of the reasons given for finding science hard were made for different groups. Those concerning course content and its organisation yielded the results set out below for juniors (Forms I - IV) and seniors (Forms V - VI). The percentages are based on the total pupils in the group, while the descending rank order, out of 24 categories of hardness identified in a preliminary study, appear in brackets.

Reasons	Juniors	Seniors
Science is 'too complicated', 'too difficult to understand'	31.3(1)	30.4(1)
'Too much in the course', 'the pace is too fast'	16.9(3)	24.7(2)
'Too many symbols, formulae and equations'	8.9(4)	11.0(4)
'Irrelevant to life and/or career'	5.4(7)	3.8(11)
'Too comprehensive', 'includes too many sciences'	4.2(9)	5.7(8)

Two matters need to be kept in mind in contemplating these results. Firstly, the percentages are minimal since additional pupils may have had similar problems without stating them explicitly. Secondly, juniors take an integrated 'Science' course and seniors one of the composite courses including at least three of the four basic sciences.

Of considerable importance to curriculum developers and to classroom teachers is the high proportion of students to whom school science has little appeal. Ranking second with juniors (18.0%) and third with seniors (20.5%) were responses such as 'Science doesn't interest me' or 'I find science boring'. Reactions in this category do not necessarily reflect on the science content alone; other contributing factors could well include the teacher's relations with the pupils, the teacher's methods, the work-effort demanded, and etc.

In addition to the group analyses referred to previously, analyses are also given and discussed of the responses to each of the 24 categories for junior boys, junior girls, lower stream pupils in Forms I and II, and upper stream pupils in the same two forms.

30. Revival of Taxonomy in Science Courses

Miller A.H. (1965), Taxonomical Studies in School Science, ASTJ, 11,1, 65-69 (May)

Synopsis

The classification of organisms was strongly emphasised in botany and zoology courses a generation or two ago. The introduction into schools of biology, mainly concerned with human biology and physiology, resulted in a decline in the need for taxonomy. This decline has been reversed in the last few years for two reasons. Firstly, interest in ecology has increased. Secondly, some knowledge of plant and animal groups is needed for the effective teaching of some biology topics such as evolution included in the new science course taken by all junior secondary school pupils in New South Wales.

Discussion

Thirty or forty years ago the chief emphases in school botany and zoology courses were on the classification (taxonomy) and the morphology of plants and animals. The ability to name as many organisms as possible seemed to be the prime purpose in studying these subjects. The introduction of biology as a school subject, with its emphasis on human biology and on physiology, meant a diminished need for taxonomy; processes, not the particular organisms in which they occurred, being of first importance.

During the last four or five years an increased interest in ecology brought with it a reversal of the decline in taxonomical studies as biologists realised the need for studying organisms in their natural environment and their interdependence. Today there is a second reason for including more work on taxonomy, chiefly as a direct result of a new approach to the teaching of evolution. Whereas previously this topic was only treated in New South Wales in Leaving Certificate biology, now all pupils in the first four years of secondary schooling encounter the theory, coupled with the study of genetics, following the introduction of the new science course leading to the School Certificate. As part of this work, emphasis is to be given to evolutionary trends and ecological adaptation. For this teaching to be effective, students need to have some knowledge of plant and animal groups. Considerable space is then given to discussion of certain problems facing those who wish to teach taxonomy as a dynamic aspect of evolution and ecology. Despite the difficulties in classification, the topic should not be avoided.

Miller, in a later paper 'Plant and Animal Diversity' (ASTJ, 11,2, 79-83, (November)), suggests methods for dealing with problems inherent in the new approach to the teaching of classification.

31. *Present Physics Courses in Australian Schools*

Shepherd S.R. (Ed.) (1971), Physics Courses in Australian Secondary Schools, ASTJ, 17,4, 83-93 (December)

Synopsis

This article consists of answers to 14 questions about the physics courses in each State supplied by a member of the State Science Teachers' Association, prefaced by a summary prepared by the editor of the regular 'Around the States' section of the journal. As in other digests in this series, only school science programs, course content and its organisation are treated. Shepherd's summary, in part, reads:

'Physics is taught as a separate subject in the two final years of secondary school (Grades 11 and 12) in most States. In New South Wales physics forms part of an 'integrated' science course'. (While the junior secondary science course in New South Wales is intended as an 'integrated' course, the senior courses are composite in nature. RWS)

'In each State, the syllabus requirements for all (senior) schools are laid down and examined by part time committees with strong university representation'.

Australian Physics Curriculum Project

The Federal Department of Education and Science is considering a proposal, presented by the Australian Academy of Science and supported by the Director-General of Education in each State, that a Commonwealth-founded curriculum development project be established for senior physics.

Discussion

In the following State sections, information will, in general, only be given where it differs from, or is in addition to, that covered in Shepherd's summary.

Victoria (W.A.F. Lang)

PSSC Physics was introduced in Grade 11 (Leaving) in 1965 and in Grade 12 (Matriculation) a year later. The syllabus committee would like to produce a new course, drawing on all available sources and tailored to meet Victorian requirements, but hasn't the manpower resources. Preparation for senior physics occurs in the junior forms in some schools, e.g. by using the Introductory Physical Science (IPS) materials but there is considerable variation in the absence of external prescription in Forms I-IV.

New South Wales and A.C.T. (P. de Beuzeville)

Physics is included in the integrated Science courses in Grades 7 to 10 and in the general and the two multi-strand courses in Grades 11 and 12. The junior course was introduced in Grade 7 in 1962 and the senior courses in Grade 11 in 1966. General dissatisfaction with the latter has led to 'Project Physics' and 'Foundations of Physics' being trialled as separate courses and also as parts of multi-strand courses.

Western Australia (C.H. Griffith)

At the end of the fifth year (Grade 12) two external examinations are set on the course covered in Grades 11 and 12. The Leaving paper (all candidates) tests widely the course with many, mainly mathematical, questions; the Matriculation (taken additionally by intending university physics students) tests application of principles in fewer questions. The present course was introduced in 1965. In 1972 all junior pupils in most secondary schools will be studying science, which will include some physics.

Queensland (J.L. Morgan)

PSSC Physics, introduced in Grade 11 in 1969 and in Grade 12 a year later, defines the senior course. The present junior science course, including some physics and introduced in Grade 8 in 1964, is factually orientated, and is incompatible with the largely conceptually oriented senior courses. However, the newly-formed Advisory Committee on Science is expected to set up general principles and concepts to be taught, without specifying details, thus allowing the schools freedom to cater for the future needs of their students.

South Australia (N. Olijnyk)

Physics is available as distinct one-year courses in Grades 11 (Leaving) and 12 (Matriculation), introduced in 1970 and 1971 respectively. Each comprises a core and three-week options, two out of seven in Leaving and three out of eight in Matriculation. Very little previous knowledge is assumed although the junior science courses include some physics content.

Tasmania (Rev. R.B. Brown)

Specialised physics will not be taught in Departmental schools until Grade 11 when the phasing in of General Science to Grades 7 to 10, beginning with Grade 7 in 1971, is complete. Some independent schools, however, will continue with separate physics in the junior grades. A three-year trial period of a new senior course began in 1970.

ON CURRENT JUNIOR SCIENCE COURSES

32. *A Survey of General Science in the Australian States*

Robins G.H. (1957), A Survey of General Science Teaching at the Secondary Level in Australia, ASTJ, 3,3, 28-35 (November)

Synopsis

A report of the results of a survey to

1. determine the provisions made for the teaching of General Science courses in Australia, and
2. make a comparative study of these courses regarding curricula, methods and techniques.

Discussion

The aims and content of the courses were obtained by analysing the relevant State-wide syllabuses and the details of the organisation and teaching from responses to a questionnaire sent to practising teachers in each State.

The Types of Science Courses in Australian Secondary Schools

A table shows for each of the six States the types of science courses (categorised as 'Separate Sciences", "Combined Science', or 'General Science') offered at both junior and secondary school levels and the age ranges of the pupils involved. This table indicates that at the junior level, General Science courses are the only science courses available in Victoria and Tasmania, General Science and the separate sciences are available as alternatives in South Australia and Western Australia, while in Queensland the separate sciences only are offered (the situation in New South Wales was too complicated to be treated clearly in the table). At the senior secondary level in each State, only the separate sciences are offered except in New South Wales where Combined Physics and Chemistry (extended from a junior course with the same title) was also available.

The Courses in General Science

Under the heading 'The Courses in General Science' the terse tabulated information is explicated and amplified for each State with regard to the organisation of the sciences at the junior stage and the content of the General Science courses. The official syllabus statements concerning integration or correlation of subject matter from the component separate sciences are quoted. In the responses to the questionnaire a two to one majority of the respondents stated that they attempted to develop an integrated approach to the subject in their teaching. Three tables, summarising for each State information supplied by the questionnaire respondents and applying to their own schools, conclude the report. The first two tables give the time in hours per week (mean and range) allocated in each category of junior courses to theory and to practical work. The third lists the textbooks used in the courses.

33. *The New Junior Science Course in New South Wales*

Barker E. et al (1963), A New Science Course in New South Wales, ASTJ, 9,1, 39-48 (May)

Explanatory Note

Although the report of the Wyndham Committee into changes thought desirable in secondary education in New South Wales was completed in 1957, it was not until early November 1961 that its principal recommendations were accepted by the State Government along with the decision to initiate their implementation with first form classes in 1962. The group of articles abstracted were each written by a person who was a member of the syllabus committee for junior secondary science, or of the team which produced the first textbook to be based on the syllabus, or, in most cases, of both. With the title of each contribution is given the name of its author.

General Principles and the Syllabus. (E. Barker)

The syllabus committee's unique task was to devise a course which would replace all existing science courses, be compulsory for every pupil during the first four secondary school years, and cater for wide differences in ability and interest.* Very early it was decided that

*Abstractor's Note: The recommendation in the Wyndham Report was that after a common first year course in 'Science' (deliberately not called 'General Science') and also at the commencement of the third and fourth years, students could opt to continue with the common core or to transfer to one or two courses in the separate disciplines. However, the Board of Secondary School Studies accepted the committee's recommendation that the only options after the first year would be extended or deeper treatment of the common core of subject matter at 'Credit' or 'Advanced' levels with the higher level materials being so identified in the syllabus.

the major concepts of the four basic sciences would be covered and that the course was to be based on experiments, observable phenomena, natural interest and modern ideas in science. With appropriate emphasis on important ideas and scientific method, a sound grasp of fundamentals would be provided for students wishing to specialise in the senior years.

Adoption of these guidelines led into the most difficult phase of all - the selection of content and its integration into a single science course. Several different approaches were developed but rejected for a variety of reasons. Under extreme pressure, due to the necessity of having the syllabus materials completed, published and in the hands of teachers within a couple of months of beginning its task, any thoughts of developing a four-year integrated course had to be abandoned. Instead, it was decided to set out the basic content from the contributing sciences separately for each science prefaced by a lengthy section suggesting different ways in which integration might be achieved. Apart from providing a suggested integration for first form teaching based on the energy theme, the problem of integration over the full four years was left to the teacher - the key person whose presentation of any course would determine its outcome. Emphasis was given to the necessity for the course being taught by <u>one</u> person, not by a team.

Probably the four most important avenues through which integration might be fostered, in the committee's mind, were:

1. the universal applicability of scientific method;
2. the interdependence of the sciences;
3. the wide applicability of fundamental ideas and concepts, in particular the concept of energy and the particle theory; and
4. the unity of nature and the convergence of the sciences.

<u>One Book with Forty-Five Authors</u>. (R.W. Stanhope)

<u>Problems in Implementing the Course</u>

Implementation of the new course into a school system in which no integrated science course had ever been taught brought to the surface some very serious problems - who could teach a course embracing four science fields?, who could teach it without a textbook?, how would pupils fare without a textbook? These opened up the further problem: if not <u>one</u> teacher could teach the course without the guidance of a textbook, much less could <u>one</u> person write that textbook.

Attempts to Solve Some of the Problems

Early in the second half of 1962 a possible solution occurred to Professor Messel, Head of Sydney University's School of Physics, whose efforts to improve school teaching, particularly senior physics, were well known. Under his leadership, with the support of the New South Wales Department of Education and with finance from the Nuclear Research Foundation, the first few months were spent in the preliminary planning of the enterprise by an editorial committee of 19 professors, teachers' college lecturers and practising teachers. Then late in November 1972, the writing and illustration of the book began on a full time basis, the Editorial Committee being supplemented by an additional 17 persons, including some with expertise in the design and execution of diagrams and other illustrative material. In the space of three weeks, four teams, one for each of the basic sciences, developed drafts of the syllabus material in a way considered suitable for later integration into a single book for the entire four year course. After considerable discussion by the whole group, rewriting much of the draft material and the writing of introductory and periodic special integrating chapters, the Executive Editorial Committee of four, including Professor Messel, assumed the role of completing what had been a monumental task.

The Book Produced

The book, entitled 'Science for High School Students' and consisting of over 800 pages with more than 700 figures and 11 coloured plates, was published in a pilot edition in April 1963 for classroom use on a trial basis by over 1000 students in Forms I and II. Feedback from the teachers of these classes and of all the other science teachers in the State and from interested educationists in the other States, all recipients of free copies of the book, is to be used in the preparation of the first generally-available edition and a teachers' manual, both planned for publication by the commencement of the 1974 school year.

Chemistry in the New Course. (J.P. Doherty)

An idea of the chemistry content of the syllabus may be gleaned from the headings under which it is listed. These may be abbreviated thus: the nature of chemistry and its usefulness; the sources; the extraction or manufacture and the uses of important substances; the differences between elements and between compounds; the different types of chemical reactions; and the representation of chemical phenomena. The subject matter is definitely oriented towards general education, for instance, advanced students only are required to study valency, formulae, chemical equations and calculations.

Carrying on the emphasis in the preamble to the whole syllabus on general principles and unifying themes, it is suggested that explanations be in terms of:

with ordinary students - particles and energy,

with credit students - atoms, molecules, ions and valency,

with advanced students - ions, electro-valency, covalency, bond energies and crystal structure.

In contrast with traditional introductory chemistry courses, there is greater emphasis upon substances of domestic and industrial importance, including a wider range of organic compounds. This feature and the large number of simple experiments which may be performed individually provide a potent means of arousing and maintaining interest.

Geology in an Integrated Science Course (F. Tebbutt)

The coverage of geology in the syllabus and necessarily in the book is very wide. In addition to the usual topics found in an introductory text, it also deals with engineering geology, geological history with reference to the geology of New South Wales, stratigraphy, geochemistry and the extraction of metals. Being an integrated course including biology, there has been no need to devote special attention to biological terminology in the treatment of palaentology, the various fossils having been included in the appropriate biology sections.

Several problems arose in writing the geological material for the textbook, mainly from the fact that to most science teachers geology was an unfamiliar subject. In an attempt to meet these problems full instructions have been given for doing practical work, particularly in geological mapping, while great restraint has been exercised with terminology.

Physics in the New Course (R.G. Cull)

The concept of Energy was the unifying theme in the physics section of the syllabus which was designed to provide some appreciation of the natural laws and their explanatory theories so that modern technology is not merely a series of 'black boxes'. The quantitative emphasis in traditional physics courses has been lessened with the idea that calculations may be used where they contribute to better understanding. As in the other branches of science included in the syllabus and in the book, experiments, most of them for the pupils themselves, play an important part in the development.

To give an indication of the physics content of the book the author of the article gives an outline of some six of the chapters. Of these, the three not usually found in physics textbooks deal with:

1. A broad picture of man's model of the physical world ranging from interstellar space to the nucleus of the atom.

2. Observational astronomy covering the stars, the solar system and the earth in particular.

3. A space trip to the moon to teach Newton's laws and biological problems associated with the establishment of life on the moon. Included in this chapter is also some geology.

Biology in the Integrated Science Course (G.R. Meyer)

While biology is part of a unified science of nature, it has its own body of facts and principles. These fundamental ideas which serve to unify the realm of biology, as quoted from the teacher's manual being published along with the textbook, range from:

'Living matter is an organisation of non-living matter which has the properties of metabolism, reproduction, growth and responsiveness', to '

'The characteristics of organisms as expressed in their adaptations are transmitted from generation to generation as genes. Natural selection selects the desirable genes in a population'.

The early chapters, emphasising adaptive biology, describe how plants and animals co-exist in communities, being adapted to the physical environment and to one another. Central to the biology section, however, is the thorough analysis of the function of man and of a flowering plant built around the cell concept. A feature of the treatment of the plant is the use of photosynthesis to illustrate the development of scientific knowledge through the application of scientific method. Near the end of the book are chapters on the diversity of life which stress adaptation and evolution. These could be best used perhaps not as teaching units but as sources of material for many topics. Thus used, the desirable goal of having a continuous thread of adaptive and evolutionary biology throughout the four-year course might be achieved.

34. *An Analysis of First Year Science Courses in Australasia*

Power C.N. (1966), An Analysis of First Year Science Courses in Australasian Secondary Schools, ASTJ, *12,1, 31-37 (May)*

Because of the very factual nature of this paper, it seems appropriate to dispense with the usual synopsis and to provide only a digest of the material presented.

The Overall Situation

In the first section, brief outlines of the science courses, including some new ones introduced in the 1960's, offered at the junior secondary level in each of the six Australian States and in New Zealand, are provided. These outlines give the titles of the courses, their duration, the areas of science included, and whether or not the science content is integrated.

Analysis of Topics

The second section comprises a detailed analysis, in tabular form, of the topics included in the 1966 first-year science syllabuses, the topics being listed under the names of the five major sciences - astronomy, biology, chemistry, geology and physics. The table also shows for each State and for New Zealand the average age, on 1 August, of the pupils and the length of the junior secondary course in years.

Several generalisations based upon the foregoing are then stated. A common course is followed in each State during the first year, thereafter courses are usually offered at two or more levels, with subject matter from the five major sciences being included in all courses.

Organisation of Subject Matter

In most syllabuses, attempts have been made to break down artificial barriers between the sciences by organising content under broad topics or by integrating some sections through emphasis upon unifying concepts, such as the energy concept or the particle theory. On the other hand, in two States, composite courses of the separate sciences are offered. Despite these differences, there is much common ground in first year courses, and even more when whole courses are considered. The increasing tendency for the newer courses to be influenced by recent overseas programs is manifest not only by organising the content around unifying concepts, as mentioned earlier, but by stress on processes, attitudes and the role of experiments in scientific endeavour.

Plea for Co-ordination of Curricula at National Level

A plea is next made for science curriculum projects to be co-ordinated at the national level by an 'Australian Science Education Foundation'. Then the present wasteful duplication of effort by each State in the development of syllabuses, books, tests and other materials unique to the particular State would be avoided. Really creative and talented specialists are in short supply in every State, hence the time is ripe for moves to co-ordinate their efforts. The recommendation is made that the lead given by a conference in 1964, which produced a 'Suggested Course of Study in Mathematics for Australian Primary Schools' should be followed. This suggested course is now being used as the basis for a new mathematics syllabus by each State. There is no intention that inflexible national syllabuses in primary mathematics or in secondary science will result from the moves under way.

The States and the Aims of Science Teaching

Substantial agreement on the aims of science teaching already exists between the States, as is shown by statements in the preambles to science syllabuses. The Australian Science Teachers' Association has recently promulgated a set of aims. Suggestions are made as to how the association might make use of these and the commonality of subject matter in the first-year courses to lay further foundations for a co-ordinated federal curriculum development project while awaiting the establishment of an Australian Science Education Foundation. See Digests 63 to 72.

35. *Recent and Pending Developments in Junior Science Courses*

Davis R.G. (1966), Junior Secondary School Science Courses, ASTJ, 12,3, 37-41 (November)

Introduction

This report outlines recent or pending developments in science courses designed for better-than-average pupils at the junior secondary school level in each of the Australian States. The report was prepared to furnish background information for participants in the discussions on science curricula held during the Fifteenth Annual Conference of the Australian Science Teachers' Association, Sydney, August 1966.

Before the courses in each State are considered, mention is made of a number of important nation-wide changes. Those relevant to these digests are: comprehensive courses including material from all the basic sciences have been introduced in all States; in the selection of content greater attention is paid to the interests, needs and abilities of the pupils and their contribution to society; and the need for understanding broad concepts rather than memorisation of detail is recognised.

Courses in the Six States

New South Wales

The new four-year 'Science' course introduced in 1962 simultaneously with the reorganisation of secondary education has just completed its first cycle. This is the only course in science available in junior secondary schools, it is compulsory for all and is offered at three levels - advanced, credit, and ordinary. Under the names of the four basic sciences, the syllabus lists the major concepts to be developed and the individual topics to be treated. While it is emphasised that the course is to be taught as one of integrated science, the method of integration is left to the teacher.

Victoria

General Science has been the only science available during the four-year program leading to the Intermediate Certificate Examination since 1945. Prior to 1962 the subject was offered at two levels, since then at one level only. While it is not an integrated course, some inter-relation is evident from the grouping of the topics which have been selected from all four basic sciences and astronomy. It is proposed that the Intermediate Certificate Examination be discontinued after this year. It is hoped that schools will not then introduce courses in the separate sciences (as was the situation prior to 1945. RWS). The syllabus is at present being revised.

Queensland

In 1964, when the period of junior secondary schooling was extended from two to three years, the former two-year courses in the separate sciences were replaced by a course called Science for the first year, and by two courses, Science A and B, for the second and third years. All the basic sciences and astronomy are represented in the courses, with Science B extending the content of the A course with additional topics in physics and chemistry. No attempt is made to integrate the subject matter; in fact, each course is a composite of sub-courses in the separate disciplines. However, an alternative integrated General Science course is provided for the less able pupils.

Tasmania

All pupils taking the four-year program leading to the School Board Certificate are required to include a science subject, but the variety of alternatives exceed those offered in any other State. A common Science course, including topics from the four main branches and astronomy, extends over the first two years for most pupils. In the third and fourth years, most select Science IIA, comprising two chosen from biology, chemistry, geology and physics; the remainder take one of three general science courses.

South Australia

Until this year, the sciences available in the three-year course to the Intermediate Certificate were: the separate sciences, a two-unit General Science, and a one-unit Elementary Science. The two latter subjects comprised separate strands of physics, chemistry, biology, and earth science (astronomy and geology). Many pupils took the General Science course in the first two years, and then physics and chemistry. As from 1966, revised courses in General Science and Elementary Science, in each of which an integrated approach is to be adopted, will be the only science courses available at the junior secondary level.

Western Australia

General Science became an examination subject for the Junior Certificate in 1945 along with the long-existing separate sciences. In 1962 it was replaced by two new courses - Science A, offered over the three years, and Science B, offered in the second and third years. The A course content is drawn from astronomy, biology, chemistry, geology and physics; the B course, for students intending to study specialised sciences in the senior school, consists of the A course together with additions in physics and chemistry.

36. A Comparison of First-Year Science Courses in Australia

Waddy R.J. (1969), A Comparative Analysis of First Year Science Courses in Australian Secondary Schools During 1966, ASTJ, 15,1, 67-68 (May)

This is an abstract of a B.Ed.Hons thesis, University of Western Australia, completed in 1967. The major purpose of the study was to determine the present state of the first-year science courses with regard to the aims and subject matter, the sources being the official public examination manuals and courses of study. Of the 220 study units .... drawn from astronomy, biology, chemistry, geology and physics .... only two were common to all States. However, the broad areas of content were found to be largely the same. A general trend is apparent in all the courses, including the alternative courses offered in four of the States, to provide basic facts and principles relating to the environment that will help pupils appreciate the impact of modern technology on society and develop a lasting interest in science. The alternative courses cater for the less academically able pupils, except in Victoria where bright pupils interested in practical applications of science may elect to take the technical schools course.

37. *Australian Junior Science Courses: Now and Likely*

Shepherd S.R. (Ed.) (1970), An Outline of Science Courses at the Junior Secondary Level in Australian States (up to and including Grade 10), ASTJ, *16, 1, 83-90 (May)*

Synopsis

A table shows for each junior secondary grade in each State the hours given to the teaching of science each week in 1970. The remainder of the paper gives for each State the present and likely future situation concerning some or all of the following: the nature of the science courses, i.e. separate, composite or integrated; course content; pupil assessment procedures; and the influence of these and of other factors on the content and teaching methods.

Discussion

Only matters concerning the nature of the science courses and their content are treated in this digest.

New South Wales (W.L. Butts)

For the 'Science' course, extending over all four grades for all pupils, the subject matter is listed under the headings: Biology, Chemistry, Geology and Physics. However, an integrated approach is to be followed stressing the unity of nature, the recognition and application of major concepts common to several sciences (e.g. the concepts of energy and the kinetic-molecular nature of matter), and the interdependence of the sciences.

The course may be taken at three levels - ordinary, credit, and advanced .... the differences being in the range and depth of treatment of the basic content. Differentiation into the levels usually begins in Form II following a common first-year course. The present syllabus dates from the 1962 reorganisation of secondary education under the Wyndham plan, although the original content was reduced by about 20% in a revision in 1967. Two other science courses are available for average and well-below-average pupils.

Queensland (G.W. Robins)

The present courses are:

Science A: Astronomy, Biology, Chemistry, Geology and Physics treated separately but correlated wherever possible. Extends over Grades 8-10 but designed as a terminal course.

Science B: Physics and Chemistry as separate sciences. Taken in Grades 9-10, in addition to Science A, by students studying science beyond Grade 10.

General Science: For less able students, topic organisation with the same sciences as in Science A.

The future of Junior Science is in a state of flux with the Radford Committee presently considering the place of external examinations in secondary education. If the Junior Examination is abolished, schools will be allowed to devise their own courses within a broad framework suggested by the Science Syllabus Committee. If the Junior is retained, the present course will need to be revised taking into consideration the new primary school science syllabus and that the traditional senior courses have been recently replaced by PSSC physics, CHEM Study chemistry, and the 'Web of Life' biology.

South Australia (D.W. Hutton)

More than twenty science courses .... some indigenous, some importations from other states and from overseas .... are being used, trialled, phased in or phased out. Some of these involve many schools, while others are very individual affairs. With the abolition of the Intermediate examination after 1968 and the active encouragement of the State Education Department, schools are now largely free to devise their own courses, making use, if they wish, of statements of general aims and objectives and of syllabus details for different kinds of courses circularised by the Department. The Department's present policies of tracking, in which different courses are available for pupils of different ability levels, and experimentation appear to ensure that for the foreseeable future there will exist a number of syllabuses and a variety of materials for junior secondary science.

Tasmania (J.G. Scott)

The science syllabuses for Grades 7 to 10 have remained virtually unchanged for about twelve years. In the belief that specialisation in Grades 9 and 10 is desirable for some students, it has been necessary to provide a wide range of content in five science disciplines in the first two years. The resultant syllabuses, overful with factual detail, are now regarded with disfavour by many. Trials of a new science course for all junior secondary pupils are due to begin in 1971. Apart from the possibility that some pupils in Grades 9 and 10 may undertake special investigations no provision for specialised courses will exist.

Victoria (S.R. Shepherd)

In technical schools, almost all pupils take science for the first four years. During the first three years, most schools follow the suggested syllabus prepared by a committee of teachers, although teachers are urged to develop their own courses. In the fourth year, culminating in the Intermediate Technical Examination, Science I is taken by most students and Science II by those intending to proceed to a course in applied science.

In the Secondary Division, schools are free to develop their own curricula. These take various forms - sometimes science disappears as a separate subject, being included in general studies, but in the majority of schools science is retained as a separate subject in Grades 7 and 8, with at least some of the JSSP materials being used. With the abolition of the Intermediate Examination in 1967, no prescribed syllabus exists for science in Grades 9 and 10, but a suggested list of topics is available from an official committee. In some of the individually devised courses, sections or ideas from the Nuffield 'O' level courses, IPS and JSSP are incorporated.

In some independent schools, reversion to separate physics and chemistry courses has occurred, and in others, courses similar to those in the State Secondary Division are offered.

Western Australia (H. Pearson)

In all government high schools and most independent schools a three-year general science course is taken. Two levels of courses have been offered in the past - Science A comprising chemistry, physics, biology, geology and astronomy and taken by all pupils; and Science B, the more quantitative aspects of physics and chemistry taken, usually along with Science A, by the ablest third of the pupils in second and third year. These courses, however, are now being phased out by an Achievement Certificate scheme beginning with first year students this year. In the new scheme, while the science courses are essentially unchanged, the emphases are on unifying the material and on understanding.

In some independent schools, science is available as separate courses in physics, chemistry, biology, and physiology and hygiene, but in most cases only after a general science-type course in first year.

ON CURRENT SENIOR SCIENCE COURSES

38. Recent Developments in Australian Senior Science Curricula

Stanhope, Roy W. (1967), Developments in Senior School Science Curricula in Australia, ASTJ, 13,1, 5-14 (May)*

Synopsis

The material in this paper is presented in six sections: (I) the major criticisms of traditional school science courses, (II) the new curriculum movement in the United States, (III) the Nuffield science teaching project in Britain, (IV) the background to recent changes in Australian courses, (V) the new senior science courses in Australia, and (VI) some recommendations for action. No apology is given for devoting so much of this paper to overseas developments, particularly American, because of their considerable influence in bringing about changes in Australian senior science curricula.

Discussion

I. The Major Criticisms of Traditional Courses

The first critics were mostly university scientists who alleged that school science did not reflect the spirit, the methods, and the subject matter of contemporary science. More specifically, the major relevant criticisms, accepted later by many teachers, are:

1. the subject matter is out-of-date,
2. syllabuses, textbooks and examinations are concerned mainly with unrelated, often trivial, facts,
3. important areas of contemporary interest are usually neglected,
4. modern material, if included, is not well integrated with other content.

Teaching methods and laboratory work are also found wanting.

*A contribution to the symposium on 'Curriculum Development Related to Changing Needs' held at the Thirty-Ninth ANZAAS Congress in Melbourne in January 1967.

II. The New Curriculum Movement in the United States

The genesis in 1956 of the first American school science curriculum project .... which, as with the later projects in the other sciences, was developed in an attempt to meet all, or most of the criticisms of traditional courses .... is outlined. A table provides for each of the new projects: the grade placement, the science subject concerned, and the date of launching. Contrasts are then drawn between the traditional procedures used in the preparation of syllabuses, textbooks, and etc. and those followed in the projects in the United States. The much greater range and variety of curriculum materials produced in the latter are listed. The remainder of this section outlines efforts in America to integrate standard one-year courses in the separate sciences into two-year physics-chemistry, three-year physics-chemistry-biology, and four-year-all-four-basic-sciences courses ..... using the materials or, at least, the major concepts of the new projects.

III. The Nuffield Science Teaching Project in Britain

The Nuffield Foundation established in 1962 a science teaching project aimed initially at preparing new curriculum materials for O-level physics, chemistry and biology, but extended subsequently to the sixth form sciences, to primary science and to non-academic secondary science. Cursory examination of the first fruits of the projects .... the O-level materials .... indicate that they may exert considerable influence on Australian school science in the future.

IV. Background to Recent Changes in Australian Senior Science Courses

The principal past and present influences on Australian secondary education, generally, and on science education, particularly, are then discussed. These include:

1. the very considerable British influence since the early years of this century,

2. the emergence of General Science courses about 60 years ago in the United States and in Britain in the 1930's, with the latter being largely responsible for the introduction of the subject in most Australian states from the 1940's;

3. the recommendation of committees, set up in most States in recent years, to suggest desirable reforms in secondary education, its organisation, curricula, and etc;

4. the influence in and out of syllabus committees of persons, particularly of those who have visited the headquarters of projects, acquainted with the procedures and products of

science curriculum reform efforts overseas;

5. the greatly increased activities of science teachers; associations, both federal and state, in urging curriculum reform, in informing members of overseas developments, and in conducting in-service courses; and

6. the efforts of university departments and individual staff members to modernise school science courses and the subject matter knowledge of teachers.

V. The New Australian Senior Science Courses

Four different methods of effecting curriculum change in Australian senior science courses are described, their advantages and disadvantages stated, and information given as to which of the methods have been adopted with particular sciences in the various states. These methods are:

1. the traditional method in which piecemeal additions are made in an existing syllabus;

2. the wholesale importation of a course developed in some other state or country;

3. the adaptation to suit local circumstances of courses developed elsewhere, and

4. the development of courses differing markedly from the traditional and reflecting, in some degree, the approach and content of the new American curricula.

The influence of the latter on Australian courses in biology, chemistry and physics is summarised in a table which also shows the year of introduction of the adopted or adapted courses in Grades II and/or 12 of the States involved.

Attention is then focussed on the very unique senior courses introduced in New South Wales in 1966. Displacing the more-than-half-century-old courses in the separate sciences and in 'Combined Physics and Chemistry' are four courses. One of them, for the non-science prone, does not distinguish between the four basic sciences from which its content is drawn. Two other composite courses, designed for the science-prone, comprise a common core of physics-chemistry subject matter supplemented by extensions in three of four contributing sciences. For those most interested and capable in science, a fourth course supplements the most extensive of the composite courses with the advanced study of topics in one of the four basic sciences. The composition and weekly period allocation for each of these four courses are shown in a table.

VI. Some Recommendations

1. Modern methods, similar to those used in America and Britain, should be followed in the development of Australian school science curriculum materials.

2. Australian science teaching would benefit more if some of the $10m. provided annually by the Federal Government wholly for material facilities were diverted to financing curriculum development by modern methods.

See also Digest 39.

39. *Overseas Influences on Australian Senior Science Courses*

Stanhope, Roy W. (1970), Overseas Influences on Australian Senior School Science Courses, ASTJ, 16,3, 65-70 (November)

Synopsis

With New South Wales excepted, almost all of the recently introduced senior courses in Australia in chemistry, physics and biology have been influenced in varying degrees by the post-Sputnik curriculum developments in the U.S.A. The following adoptions have taken place in the last four or five years: BSCS, modified to suit Australian conditions, in five of the six States; and CHEM study and PSSC each in two States. In cases other than those mentioned above, trials are under way of American materials, with or without modification, or of new indigenous courses. The Nuffield O-level materials, available since 1967, have had only minimal impact, being for a different age range while the Nuffield senior materials are still being developed.

Discussion

This survey reports information or opinion supplied early in 1970 by a senior science administrator in each of the six State Education Departments. The situation in Australia with regard to influences on senior science curricula as at the end of 1966 was given in a paper by Stanhope published in the Australian Science Teachers' Journal in May 1967 (see Digest 38). Hence this article presents some account of developments during the last three years.

The BSCS materials, modified to suit Australian conditions, have been 'very successfully' adopted in three States and are scheduled for adoption in Queensland (1970) and Western Australia (1971). Only in New South Wales have the BSCS materials had no influence. CHEM Study was 'very successfully' adopted in Queensland in 1968 and 'successfully' in Western Australia in 1969. 'Success' is claimed for the PSSC materials which replaced the previous courses in Victoria in 1966; a similar replacement is occurring in Queensland this year. The other American materials have had little or no effect on existing senior science courses in Australia while the Nuffield (British) senior materials are only now being developed. In the paper the above information is set out in greater detail in two tables, and, in a third, details of the trials mentioned below.

Trials of 'largely indigenous' and of 'adopted' or 'modified' BSCS, CHEM Study, and HPP (Harvard Project Physics) materials are being or are about to be conducted in all States which have not recently changed their courses.

A very small minority of the new courses introduced over recent years in Australia has made use of the major conceptual schemes of the particular discipline in the selection and organisation of content, an approach widely publicised by the National Science Teachers' Association (U.S.A.) in 1964.

See also Digest 38.

40. *The Place and Nature of Biology at the Senior Level*

Morgan, L.Robin (1970), Biological Education in Senior Secondary Schools in Australia: A Summary, ASTJ, 16,3, 79-84 (November)

The information in this summary was obtained from papers presented at a conference on 'Biological Education in Australian Secondary Schools' held on 5-8 May 1970.

Since 1966 the subject biology has undergone marked changes in most States. The materials developed by the Australian Academy of Science School Biology Project, and based upon the BSCS materials, have been adopted for the senior biology courses in South Australia, Tasmania and Victoria in 1968 and are to be adopted in Queensland in 1970 and in Western Australia in 1971. The first half of the materials is used in Grade 11, at the end of which in a few States a public examination is held; and the remainder in the matriculation year (Grade 12). In New South Wales, biology has not been a separate subject but a component of combined science courses with the exception that students taking the 9 periods per week course extend their studies in one discipline, e.g. biology during a further 2 periods per week. Trials of the Australian-modified BSCS materials, for a 6 periods per week subject over Grades 11 and 12, are scheduled to commence in New South Wales in 1971.

In some States other biological subjects are available, e.g. zoology (Queensland), agriculture (Victoria and Western Australia), and Human Biology or Physiology and Hygiene as alternatives (Western Australia. However, information about these other subjects is incomplete; for instance, agriculture is offered in New South Wales.

The summary concludes with a table showing for each State the number and percentage of students taking the different biological subjects in Grade 12 or in Grade 11 (Western Australia).

41. *A Survey of Senior Chemistry Curricula in the States*

Butts W.L. (Ed.) (1970), Chemistry Curricula in Senior Secondary Schools in Australia: A General Survey. ASTJ, 16,2, 57-66 (August)

Synopsis

In each State uniform senior chemistry courses are prescribed by a statutory board. After trials the CHEM Study course has been adopted recently in two States and is expected very soon in a third. In two of the other States new indigenous courses have been introduced in recent years but in one of these, New South Wales, dissatisfaction with the new courses has resulted in the trialling of the CHEM study materials. Tables showing for each State (i) an analysis of the content of the syllabuses and (ii) data concerning chemistry in the senior public examinations are provided. The bulk of the report is then devoted to treatment, in separate sections for each State, of the objectives, implementation and evaluation of the courses.

Discussion

Introduction (W.L. Butts)

Each State has its own senior chemistry syllabus or syllabuses. Small scale trials of the CHEM Study materials have preceded its adoption state-wide in Queensland in 1967 and in Western Australia in 1969 and its expected adoption in Tasmania within a year or two. Locally produced untrialled courses operate in the other three States. In Victoria revision of the matriculation (Grade 12) course has been completed recently and that of Grade 11 is in progress. The South Australian senior courses are also being revised. Widespread dissatisfaction with the senior science courses, of which chemistry is a component, in New South Wales is expected to lead to the trialling in 1971 or 1972 of a new 12-period multi-strand course and new 6-period courses in the separate disciplines, including CHEM Study.

'The Web of Life' senior biology curriculum, initially developed in a two-State project sponsored by the Australian Academy of Science, now operates in all States except New South Wales. Discussions are proceeding which may lead to a similar approach to the production of courses in the other sciences.

A table shows the presence or absence of 18 broad areas of chemistry in the senior syllabus of each of the six States. In a second table are given for each State in 1969 the numbers of candidates for the whole examination and for chemistry,and details of the length of the paper and of the types of questions set.

New South Wales (A.J. Watson)

Chemistry in fifth and sixth forms is part of a co-ordinated science course designed to avoid duplication of topics, explanations and variations in explanations. A physics-chemistry core on the structure and properties of matter provides a basis for the study of other topics in physics and chemistry and of topics in biology or geology. A sequence of core chemistry studies, commencing after a treatment of motion, is outlined. On completion of the core the lobe chemistry, designed to develop an understanding of some important aspects of the discipline, is to be commenced. The best students who take the most advanced chemistry course ('first level') elect from a list of seven topics.

Students not intending to study science in a tertiary institution may elect a broad course, 'The Universe as the Environment of Man', of which chemistry is a component.

Victoria (N. Henry)

The present matriculation (12th Grade) course materials .... a textbook, a practical manual and a teacher's guide .... were written by a team of five, including one practising teacher. The textbook, 'Chemistry, A Structural View', defines the course which was first taught in 1966 but without prior classroom trials. A revised edition of the book will be available later this year.

A separate course, 'Leaving Chemistry', which is offered in Grade 11 has remained unchanged since 1962. However a new course to provide a better background for the matriculation course is undergoing trials and is expected to be widely adopted in 1972. (See Digest 84).

South Australia (P. Schodde)

Chemistry as a distinct subject is not taught in most schools until the fourth and fifth years where two separate, but with some overlap in content, sequential courses are offered. Prior to 1969 the fourth year

(Leaving) course could assume completion of the separate chemistry (and physics) courses at the third year (Intermediate) level. In that year a 'new' course, little different in content from the previous, became necessary to cater for students with only a General Science background. Although intended to be an interim syllabus, pending changes associated with a shift in matriculation from the fourth to the fifth year, it is still in use. To meet the new requirements the previous, mid-fifties, matriculation syllabus was pruned by, ostensibly, one-third of its length. The course is content based and comprises three sections: Physical and Theoretical, Inorganic and Organic Chemistry.

Western Australia (G. Mueller)

The chemistry syllabus used since 1968 for both the Leaving and Matriculation examinations is virtually that covered in the original CHEM Study textbook. The last examination on the older, more conventional syllabus will be held this year. The CHEM Study course has been criticised for its poor approach to volumetric and qualitative analysis and for its wordiness.

Tasmania (L. Strickland)

CHEM Study was first considered as an alternative course and trialled in a number of schools last year and this. It now seems almost certain that it will become the syllabus within two or three years, normally as a two-year course but may be covered in one year by some students.

Queensland (G. Dettrick)

Apart from the statement in the introduction to this survey that CHEM Study, after trials in two schools in 1966, was adopted State-wide in Queensland in 1967 the only information supplied to the collator was that taken from the 1968 'Report of the International Clearing House on Science and Mathematics Curricular Developments'. Amongst the Purposes and Objectives of CHEM Study are: the preparation of some students for further studies in chemistry, and to further in the others an understanding of the importance of science in current and future human activities.

42. *An Analysis of Present Australian School Geology Courses*

McDonnell K.S. (1969), Australian Geology Courses Today: A Comparative Analysis, ASTJ, 15,2, 5-10 (August)

Synopsis

This report is concerned almost exclusively with senior school geology courses; at the junior level in most States geology is only a strand in general science courses. In turn the author treats the introductory material to each syllabus, including aims and method of approach; a tabulation of the major topics by States, with comments on relative emphases; practical work and excursions; and text and reference books. The paper concludes with a general summary and several conclusions, chiefly that cooperation between the states in syllabus construction is desirable with cognisance being taken of overseas curriculum developments. Several reasons are given as to why Australia is in a unique position amongst English-speaking countries to give leadership in the teaching of geology at the senior school level.

Discussion

Geology is included in the approved secondary school courses of study in all the Australian States. At the senior level, it is a separate subject except in New South Wales where it makes up one segment of composite science courses. At the junior level in most States it is not available separately but only as a component of general science courses. Senior courses in geology only are discussed in the rest of the paper.

Two tables show that 15 of 22 subject matter areas of geology are found in the senior syllabuses of all six States. Differences between the States as to the treatment of, and relative emphasis on, particular areas are mentioned and discussed.

In the 'Summary' it is stated that Australian geology syllabuses are mainly lists of factual content set out more or less systematically according to the generally accepted framework of the discipline. The processes of science, the distinction between major concepts and observational detail, and the way in which geological thinking has developed and is still expanding receive little attention. The importance of practical work and excursions is stressed, but these are mostly of the formal traditional kind.

In the 'Conclusions" two points arise from the foregoing discussion. Firstly, greater interstate cooperation between the syllabus planners could result only in richer and more balanced courses through sharing of ideas. On the matter of having material relevant to the local scene the suggestion is made that it would be more meaningful for students to have an overall view of the geological structure of the continent and then a more detailed knowledge of their own or of an accessible environment rather than of their whole State. On the second point, that of taking advantage of overseas curriculum developments, it is mentioned that only in America has earth science curriculum development been tackled on a large scale. While it has much to offer in the way of fresh insights and new and stimulating methods of presentation, the Earth Science Curriculum Project is designed for junior secondary school students with a very different educational background from Australian children.

The English-speaking country from which major advances in senior geology teaching could, and should, come is Australia. Amongst the reasons given for this view are: the revolution in other branches of science education occurring in every State; our long experience with six different, though related, courses of study; and the unprecedented mineral boom.

SUGGESTED CHANGES IN SCHOOL SCIENCE GENERALLY

43. The Need for the Modernisation of Science Content

McLean K.W. (1955), What is Wrong?, ASTJ, 1,1,14 (May)

A plea is made for the modernisation of the content of school science courses.

The vicious circle of the shortage of science graduates from universities, of trained science teachers in the schools, and of scientifically enthusiastic students entering universities could be the fault of the content of school science courses. Much class time is commonly spent on the discoveries of famous scientists of past centuries (fifteen are named as examples) whereas their work is by now sufficiently established for axiomatic treatment in school courses. Then in the class time saved, and since ability in language, mathematics and science correlate highly with intelligence, there is a basis for considering that those students who take our present science courses could assimilate modern scientific concepts. Teaching science in an attractive twentieth century way will help break the vicious oircle so that graduates will not shudder away from teaching science in schools.

44. Nuclear Science Topics should be included in all Courses

McKenna V. (1958), Reorientation of Science Teaching for the Nuclear Age, ASTJ, 4,3, 35-37 (November)

Synopsis

Because we are science teachers, irrespective of the onset of the nuclear age, we must keep our teaching up-to-date. The kinds of information about nuclear science which our pupils, as future educated citizens, should acquire are indicated. Emphasis is also given to the social responsibilities of scientists.

Discussion

The topics which should be treated, no matter what field of science is being taught, include the meanings of terms met in everyday life e.g. isotope, cosmic rays, fission and so on; the nature, types and effects of radiation; shielding; the uses, beneficial and harmful, of radiation and of radioactive materials. Such information should be incorporated into the regular subject matter, not treated in isolation.

In stressing the social responsibilities of present and future scientists three instances, all of a non-nuclear nature, in which such responsibilities have not been faced are given.

45. *Modernised Science Courses for All Pupils*

Stanford R.W. (1962 ... nce and Learning, ASTJ, 8,2, 11-19 (August)

Synopsis

Science syllabuses need modernising; much of the present material, retained from the 19th century, should be discarded. Because it enters into almost every facet of our everyday lives science should be compulsory for all pupils, not overlooking the needs of the prospective specialists. To provide for flexibility and receptivity to future developments a basic training in fundamentals is necessary. In General Science courses a limited number of topics should be treated in depth rather than a superficial treatment of many topics. With horizontal, not vertical, divisions of subject matter a principle or a method can be shown to apply in all the basic sciences. The scrapping of existing syllabuses and starting afresh would be a monumental task but it must be undertaken, with science teachers as a group taking the initiative.

Discussion

Science Finds a Place in British Schools

Insistent demands in England for the introduction of science into school curricula, spurred on initially by the revelation in the mid-19th century of the undoubted superiority of European technicians over the British, eventually led to the widespread introduction of physics and chemistry into boys' schools and biology into girls' schools in the last quarter of last century. The great national emergency of World War I again focussed attention on science with the result that science teaching in secondary schools assumed much the same place and shape as it does now. It seems that Russian achievements in space travel and nuclear research have provided much of the stimulus for the recent efforts in the U.S.A. (PSSC) and Europe to modernise science curricula. Science teachers should maintain leadership in such matters, not waiting for any emergency situation to galvanise them into action.

Science Should be for All Pupils

Because almost all aspects of our environment, our material wellbeing and our 'intellectual diet' are affected by science it follows that suitable science courses for all children must be devised, not neglecting the needs of the few who will later specialise in one or more branches. The needs of governments and industries for more scientists and technicians, irrespective of the reasons for such demands, should be met in technical institutions, not in the secondary schools.

On the matter of what to teach, the author is very critical of the content of the 'arid desert which often passes for school science'. The 12-year old displays enquiring wonder as he surveys the modern marvels of jet aircraft, space travel, television, modern medicine, and so on, but his next few years are spent in learning facts, formulae, symbols and quantitative skills dealing with matters having only the remotest bearing on everyday life.

Reference is then made to the common failings of the products of exposure to secondary school science, followed by a lengthy section on science teachers, including the world wide shortage, and teaching methods.

School Science Needs Modernising

Consideration of further historical aspects of science teaching in England leads into the statement that the only difference between an English Physics syllabus of 1896 and a current one for Leaving Physics (presumably Western Australian) is the addition of some modern work in the latter. This and other tinkering about with syllabuses seems typical of what has happened during the past half-century. In Physics, and probably also in Chemistry and Biology, the present type of syllabus suits neither the needs of the specialist nor of the non-specialist. Because of the rapidly accelerating advances in all the sciences, it is essential that both secondary and tertiary institutions should provide a basic training in the foundations of the subject so that the student will be receptive of new ideas and resilient to unforeseen future developments. In addition, the art of communication, largely neglected, must be improved, perhaps by taking into account in the marking of examinations not only the science content of the answers but also the mode of presentation and the standard of literacy.

General Science: Its Reorganisation and Content

Regarding General Science the author believes in the correctness of the original purpose behind its introduction in England in the mid-1930's, i.e. that all children should be taught science to the age of at least 16. Basically correct also is the original idea that a restricted number of topics should be treated in depth and not the 'veneer of watered-down and jumbled-up specialist teaching' of present

General Science courses. Better even than this last idea would be to establish horizontal instead of vertical (specialist) divisions of subject matter and to show how the principle or the method applied in all the basic sciences.

Despite the fact that it would be a monumental task to scrap existing syllabuses and to start anew it should be done. It is up to science teachers' organisations to initiate moves 'for the rejection of the old order of alchemy and the establishment of a new order with an imaginative approach to science and learning'.

46. *The New Deal for Science Conference, Sydney, 1961.*

Cull R.G. (1962), The New Deal for School Science Conference, Sydney, Saturday, 25 November 1961, ASTJ, 8,2, 59-62 (August)

This largely-attended conference of science teachers and others dealt with several different aspects of science education in New South Wales secondary schools. The principal decisions relating to curricula were:

1. The junior syllabus is in urgent need of revision to provide pupils with a far more satisfying experience in the subject. The heavy failure rate in junior science and the large number of pupils leaving at the end of the third year are partly due to a teaching syllabus which, while modern in 1910, is now quite out of step with recent developments.

2. School science syllabuses, especially those for junior pupils, should be designed to capture their interest and imagination and help to ensure that future citizens would be better informed on scientific matters. The coming implementation of the Wyndham plan affords an opportunity to introduce such a course, which, because of its importance and the urgent necessity for its preparation, is beyond the power of a part-time committee. Instead, a full-time committee should be given the task of preparing a modern junior science syllabus integrating the important fundamental concepts of all the basic sciences.

47. *How Science Teachers Can Keep Up with Modern Advances.*

Kleinschmidt B.N. (1967), Accepting the Challenges of Science Teaching, ASTJ, 13,2 5-8 (August)

Synopsis

This paper deals mainly with the greatest of all problems for science teachers - that of keeping their science knowledge up-to-date. This problem should be faced immediately, since in Queensland two new courses in which obsolescent material has been replaced by mid-twentieth century advances have already been introduced, while another two, thereby covering all the principal junior and senior sciences, are to follow. Ways of keeping informed of advances in scientific knowledge are suggested to science teachers. Other challenges, including those of the laboratory and its efficient use, are also discussed.

Discussion

The doubling of scientific information every fifteen years, as claimed by many, does not present a serious problem to teachers while school science courses remain relatively static. In such cases, new advances in science take the role of additional extras which may or may not be passed on to students. However, with the introduction in Queensland of new courses .... a five-branch General Science at Junior Level, CHEM Study Chemistry at matriculation and news of PSSC Physics and BSCS Biology to follow .... our complacency has been shattered. In these courses, attempts are made to adapt mid-twentieth century science to the classroom.

The warning is issued that science teachers, both young and old, must keep abreast of new developments in science and must be prepared to replace obsolescent material, no matter how great the attachment to the latter. In order that teachers will have ample time to adjust to new ideas, advance notice of impending changes is essential.

Three suggestions are made as to how the science knowledge of teachers may be kept up to date.

1. Reserve time, one night a week, is suggested, for reading magazines and journals such as the Scientific American and the Journal of Chemical Education.

2. Institute refresher courses so that every science teacher has at least a fortnight's in-service training every two years.

3. Maintenance of active membership in the Queensland Science

Teachers' Association which, through its journals, guest speakers, conferences, and etc., assists members in keeping contact with scientific knowledge and endeavour.

48. *Objectives for Senior Science Courses.*

Aims Committee of the Newcastle and Districts Association of Science Teachers (1967), Objectives for Senior Science Courses, ASTJ, 13,2, 45-53 (August)

Synopsis

This paper presents a proposed set of objectives suitable for science courses at the senior level. In order that they might provide an effective guide for syllabus construction, the objectives have been expressed in terms of the kinds of student behaviour that could be expected from the course. Implications for syllabus construction are then derived from the statement of objectives.

Discussion

This project arose out of criticism, made at a meeting of the Association in August 1966, of certain aspects of the new science syllabuses introduced early that year in New South Wales. It was considered that some of the major defects arose because clearly stated objectives had not been used to guide the construction of the courses.

The recommended objectives are first given as very general statements, one covering each of the three domains - cognitive, affective, and psychomotor; then each of these is broken down into a number of specific aims. Next follow an expansion and interpretation of each specific aim in terms of a sampling of the types of behaviour that could be expected from a student who has made progress towards a particular objective.

Implications of the aims for the construction of a senior science syllabus are treated in the concluding portion of the paper. Those concerned with the extent of the syllabus are:

1. Syllabuses must be so designed as to promote progress to cognitive abilities at higher levels (in Bloom's Taxonomy) than those implied by the traditional type of syllabus.
2. This change in emphasis implies that the subject matter listed in traditional syllabuses must be drastically reduced to allow students time to practise the higher intellectual skills, examples of which the committee has given.

A number of considerations which would influence the selection of subject matter items for the syllabus are listed. Some of these follow.

1. Concepts and principles which students should be able to recall, to understand and to apply include trends in the periodic table (chemistry), relativity theory (physics), mechanisms of genetics - R.N.A., D.N.A. (biology), and sedimentation (geology).

2. One or more topics should be suitable for teaching by the case history approach.

3. Some items taking students to the 'frontiers of science' should be included, provided they are within the students' capabilities.

4. The content should illustrate the main integrating themes of science.

Some implications of the aims regarding practical work are also stated.

49. *Proposal for a Senior Science and Society Course*

Sadler R. (1967), Science Teaching - What For?, ASTJ, 13,2, 19-23 (August)

Synopsis

A plea is made for the introduction at the senior secondary level of a new kind of course designed to give students an appreciation of the effects of science on society. Such a course would be taken by all students whether or not bound for scientific careers.

Discussion

The majority of students fail to appreciate the effects of science on society or the value of scientific methods of enquiry because of their pre-occupation with learning the facts of science in preparation for external examinations. The vocational and disciplinary aims of science teaching are discussed, the first from the point of view of being partly irrelevant at the school level, and the second of being often thwarted because of examination pressure.

Science and Liberal Education

Further justification for science teaching is to be found in its contribution to liberal education, an aim more appropriate to the secondary school than to any other institution. Those students who do not enter scientific technological professions but become lawyers, writers, politicians, business men, doctors - even teachers! - are the ones who must become scientifically literate. They may have understood much factual science, but only as a means to matriculation, soon to be forgotten.

A Recommended Non-Specialist Course for All Seniors

Commended to the attention of every science teacher is the Policy Statement of the Association for Science Education of the United Kingdom. This statement suggests that two courses be offered in the senior school, Course A for all students and Course B (similar to present matriculation curricula) additional for science specialists. Course A, which the author seeks to have introduced in Australian schools, should be restricted to the senior level because young students are not sufficiently mature to appreciate the value of such a course. The course should include selected episodes in the history of science and case studies of the creative work of individual scientists correlated with topics of immediate interest to senior students. Specific examples of history or case studies which could be included are mentioned. Only a few should be treated and these substantially, rather than a large number superficially. Conant in his 'On Understanding Science' provides a well-developed exposition of the same idea.

Present science courses are of little value for the student who does not continue study at higher levels, but a course designed along the lines described would provide the essential rounding off of science studies for students whether or not they intend following scientific careers.

50. Environmental Problems and School Science Teaching

Kirk J.T.O. (197?), Science Education and the Environmental Crisis, ASTJ, 19,4, 5-14 (December)

Synopsis

The features of man's present situation which have tended to bring about an environmental crisis are discussed. If the crisis is to be avoided, the nature of the problems must be understood and solutions found for them. It is the responsibility of science teachers to ensure that the next generation understands the predicament and what can be done about it. Suggestions, in some depth, are then given for the treatment of topics in physics, chemistry and biology which will make school science courses even more relevant and interesting than they were before.

Discussion

The features of man's situation in the 1970's on which attention is focussed are:

1. the exponentially increasing world population,

2. the exhaustion of non-renewable natural resources,

3. the pollution of the environment,

4. the destruction of natural habitats and the extinction of many forms of animal and plant life, and

5. the deterioration of urban life.

Given then that our environment is in a precarious state and growing worse, where do Australia's science teachers fit in? The crisis can only be avoided if the nature of the problems is understood and solutions found for them. As science teachers you have the ability and the responsibility to ensure that the next generation understands the nature of man's environmental predicament and what can be done about it.

Outlines are then given of topics, relevant to the issue, which might provide interesting and rewarding discussions with pupils. These topics are in:

<u>Physics</u> - kinds of energy resources: fossil fuel, nuclear power, water, solar energy - the future outlook, their relative impact on the environment.

<u>Chemistry</u> - air pollution; bio-degradability of organic compounds, e.g. soaps, detergents, plastics, pesticides; depletion of ore reserves, of phosphates.

<u>Biology</u> - conservation, management of nature reserves, controlled burning.

While none of us should be happy about environmental problems, their discussion in school science courses should add to the interest and relevance already present in such courses.

SUGGESTED CHANGES IN PARTICULAR SCIENCES

51. A Suggested Junior Biology Course

Mortensen K.G., Rev.Bro. (1958), Man and His Neighbours: A Condensation of Biology, ASTJ, 4,2, 13-24 (August)

Synopsis

A set of notes is provided covering a biology course for forms two, three and four in Victorian secondary schools, although in their preparation the relevant syllabuses of the examining bodies in Victoria, Western Australia, Tasmania and South Australia were examined.

Discussion

After discussion of some of the problems encountered in implementing new junior secondary science courses, stress is placed upon the fact that biology, in particular, will continue to be in serious trouble due to large classes, heavy teaching loads and inadequately prepared teachers until 'an accurate and highly simplified' treatment (of biology) is available.

The course, meeting these requirements and as outlined in the notes, devotes considerable attention to man while reference to modern problems facing us has not been neglected. The material is set out under 19 sectional headings beginning with 'Cells and the Organism' and 'Naming and Classification of Plants and Animals' through 'Interdependence of Living Things' and 'Growth, Disease and Death', and, lastly, 'The Origin of Life'. It is emphasized that the notes must be given as much 'background', especially of an experimental character, as the teacher can manage.

52. The Place of Biochemistry and Physiology in Biology Courses

Miller A.H. (1960), Biochemistry and Physiology in School Biology Courses, ASTJ, 6,1, 4-11 (May)

Synopsis

Biochemistry and physiology when included in biology courses give a coherence which would be lacking in their absence. With the coming of Biology and General Science as full subjects in schools, the concentration on the teaching of numerous isolated facts in the older Botany, Zooology and Human Physiology courses must change to an emphasis on general principles.

Discussion

Biochemistry, particularly, is of importance in revealing the general unity of life, something difficult if not impossible in separate courses in botany and zoology. This it does by showing that certain chemical reactions are common to all living organisms. Also a knowledge of the chemistry of particular physiological reactions aids the student in appreciating their complexity and, simultaneously, in obtaining some understanding of the role and value of enzymes in the chemistry of life. The difficulties experienced in teaching the different stages in the digestion of proteins, carbohydrates and fats would be largely overcome if pupils knew something of the nature of amino acids, peptide linkages, fat molecules, etc.

Prominence given to the relationship between physiology and anatomy, between function and structure, makes biology a living subject and hence helps to arouse and sustain the interest of pupils. Another valuable feature of physiology is its use in the application of biology to problems of health, of nutrition, of the food industry, etc.

A list is then given on the many topics in school biology courses which involve some aspects of biochemistry or physiology, or both. These topics can only be taught effectively if pupils are first given some fairly basic chemistry, which the author then proceeds to outline.

The remainder, the bulk, of the article is devoted to concrete suggestions for the treatment of material which, while not really essential for the final (public) examinations, if learnt by pupils will increase their understanding of the subject.

53. *Risks in Reforming Biology Courses*

W. Stephenson (1965), Trends or 'Bandwaggons' in Biology, ASTJ, 11,2, 55-59 (August)

Synopsis

Biology is in a state of turmoil because of uncertainty as to its scope, of so much to be covered as to be unmanageable, and of its rapid and continuing growth. The breadth and depth of biology is clearly indicated and several new growth points discussed. If, in attempts at reform, there is much culling out of old subject-matter to make room for new, there is the risk that the core of the science - the study of organisms - will be lost. In some States 'integrated courses of biology' have been introduced; these stress common areas of cytology, genetics, and biochemistry. While they reduce the overlap between zoology and botany, only in ecological sections is other than lip service paid to integration; in reality they have alternating sections of the two sciences. General science is not now well received overseas, and the author wonders if the same will happen to general science and 'integrated biology' in Australian schools.

Discussion

The Scope and Depth of Biology

Biology in its larger meaning is the science of life, but it has more restricted meanings. The breadth of biology in its wider sense is enormous, about one million species of animals and one-third that number of plants have been scientifically described. In depth, the range is again immense, since any animal can be considered in relation to its fellows in a sociological sense, to its behaviour in a changing environment, and so on to a total of fifteen or so aspects. Biologists are faced with the task of coping with such a frighteningly vast body of knowledge while retaining coherence between the parts.

The New Areas of Biology

Several comparatively new areas of biology have been developed since about the beginning of this century. These are cytogenetics, experimental biology, ecology, and cytobiology and molecular biology. Spectacular advances have been made in these areas, both in pure science and in applications bearing directly or indirectly upon man, his animals and plants, and, in fact, most aspects of his environment. Because these advances lie in the no-man's land between zoology, botany, bacteriology and biochemistry, they affect them all and a re-appraisal is necessary.

Accommodating the New

With so much new material, the obvious reaction is to discard some of the old to accommodate the new; this has happened in zoology and botany regarding genetics, experimental biology and ecology. The danger lies in the fact that if there is much more pruning back, the core of biology - the study of organisms as such - will be lost. Some people believe that such a loss should be expected. They include a number for whom molecular biology has become more than a trend, but rather a 'band-waggon'. At the university level inclusion of new developments is possible only if longer courses or increased specialisation is accepted.

Effect on School Biology

How are the schools affected? One move, evident in several States, is to have 'integrated' courses of biology with emphasis upon the common areas of cytology, genetics and biochemistry. While such courses reduce the overlap between botany and zoology, it is only in treating ecology that more than lip service is paid to integration. In reality these courses comprise alternating sections of botany and zoology. Based on recent American experience the author believes that 'there is nothing so differentiated as a so-called integrated course'. While such experimentation in the organisation of courses is desirable, it can be very disconcerting at the school level.

Some Warnings

The author wonders whether the low level of satisfaction overseas with general science is likely to happen with general science and 'integrated' biology in Australian schools. The paper concludes with the admonition that it is bad science to introduce such sophisticated concepts as the Krebs cycle to students unable to appreciate how the information was obtained and without the chemical and biological background to know what it is all about.

54. *The Social Relations of Chemistry.*

Martin M.L. (1955), Teaching the Social Relations of Chemistry, ASTJ, 1,3, 9-10 (November)

Synopsis

Through a different approach in school chemistry the average educated citizen may be led to acquire an attitude of mind that sees the factual matter in relation to the social and economic background and hence to add to the human-interest aspect of the subject.

Discussion

If the social relations of chemistry are to be effectively used in our teaching, the discoveries of great scientists must be presented against the social and economic factors at the time. Geographical and historical reasons for the development of a local industry or for the use of local sources of raw materials will heighten interest and may prove a useful starting point for discussing their chemistry. Reference is made in this connection to the development in South Australia of the Solvay process, the large-scale production of sulphuric acid and the exploitation of Iron Knob minerals. Advantage can be taken of these and of local situations elsewhere in Australia to give life and reality to the bare bones of chemistry.

55. *Modernising School Chemistry Courses.*

Allen J.A., (1962), School Chemistry in the Sixties,
ASTJ, 8,1,14-20 (May)

Synopsis

School chemistry courses are severely criticised for their retention of unnecessary and restrictive concepts of nearly a century ago with the neglect of developments since then. Much of the paper is given over to consideration of chemical equilibria as an example, leading from the nature and cause of the problem through some possible palliatives and cures to an outline of the modern thermodynamic approach. The suggestion is made that chemistry courses be based upon modern principles and organised under two headings, (i) the properties of chemical substances and (ii) the dynamics of chemical change.

Discussion

. the very rapid growth of the chemical literature in the past ec or two, there is a primary need to devise school chemistry courses 'in sympathy' with modern developments, ruthlessly discarding obsolescent material. The author uses 'in sympathy' to emphasise that 'it is far from being suggested that school courses should represent the present state of the science on unreadable microfilm'. In order to make clearer his intention, the main steps in the thermodynamic approach to chemical equilibria are then given. Since both an historical and a formal approach to the topic would be disastrous at the elementary level, the only way open is to accept developed ideas with the aim of obtaining an appreciation by application.

After mentioning that principles other than the thermodynamic might well have been used in illustration of an approach in sympathy with modern developments, the paper concludes with the suggested organisation of chemistry mentioned in the synopsis.

See also Digest 56.

56. *Changes in University Chemistry Courses Affect School Courses*

Hambly A.N. (1964), Chemistry Feels the Winds of Change,
ASTJ, 10,2, 53-59 (August)

Synopsis

Obsolescence of the content of science with the passage of time since their training period and its replacement with modern material are challenges facing science teachers. The kinds of changes which have occurred recently in university chemistry courses are described and then an indication given of their effects on school courses and on the selection by pupils of the subjects affording the best preparation for university studies in the sciences. Following a discussion on the question of facts or principles the statement is made that a modern syllabus must have a proper balance of both.

Discussion

Teachers, as teachers, are conservative and resist change, hence proposed syllabus changes should be publicised far enough in advance of their implementation to allow time for discussion of the new material at summer schools or conferences.

Changes in University Courses

Of the changes that have occurred recently in university chemistry courses, those in the first year particularly have influenced school courses in several ways. Firstly, the subject has become increasingly dependent on physics and mathematics, but those university students who turn to biology because of lack of confidence in their mathematical ability find that a pass in Chemistry I is required of biology specialists. Indeed, most biologists believe that school physics and chemistry provide a better basis for their subject than school biology.

Secondly, university chemistry courses have become more sophisticated in certain areas such as thermodynamics and quantum mechanics, but, while this may not affect school chemistry courses much as far as quality is concerned, caution needs to be exercised as to quantity. Thirdly, there has been the deletion of obsolete or obsolescent material such as the traditional qualitative analysis by the wet-way method.

Little Change in School Courses in More Than a Generation

Changes in first year courses have been much less than in higher years and the changes in the secondary school courses in many States have been minimal. For instance, the author states that the only major items in the present New South Wales Pass and Honours syllabuses not included in his own school course thirty-eight years ago are atomic structure and valence, nuclear chemistry, and 'a mnemonic masquerading as the 'laws' of the activity series'. Of the obsolescent material that should be discarded is the Victor Meyer method of determining molecular weights. Devised in 1878 it had a useful life for a half century, but has not been used by professional chemists for many years.

Facts and Principles

Many teachers are dissatisfied with the factual details in school chemistry courses and find teaching them dull. While it is more exciting to some to expound principles, it must be remembered that principles have no meaning apart from facts. The limited validity of principles presents difficulties for the teacher. This is illustrated by reference to the stock experiment for demonstrating the characteristics of a chemical change and the law of definite proportions - the reaction of iron filings and sulphur.

See also Digest 55.

57. *Geology Deserves a Greater Share in School Science Offerings.*

Hill D. (1960), Geology as a Subject for Secondary Schools, ASTJ, 6,2, 59-60 (August)

Synopsis

Geology deserves more than its present, very insignificant, share of school science offerings. Not only are career opportunities for geologists more numerous now than ever before, but geology is a background subject to many other careers and occupations. Amongst its other advantages, if taught at school, is the contact its pupils make with the non-mathematical sciences, the introduction to increasingly popular hobbies and its contributions to the individual's cultural development.

Discussion

Science teaching in schools today is heavily biased in favour of the mathematical sciences as against the living sciences such as botany, zoology and physiology. Geology comprises two parts, one closely akin to chemistry - petrology, mineralogy and the geology of metals, the other closely related to the living sciences - fossils, sediments and petroleum. Students taking geology, including some who might otherwise become misfits in physics and chemistry, might well find through it an interest in the life sciences.

Geology could be an alternative to general science since it includes some aspects of all the basic sciences as well as of geography. No journey can fail to interest a geologist with his knowledge of how different types of scenery have come about. As part of the general education of boys destined for a pastoral life, geology has a distinct contribution to make as it does also to those whose hobby interests lie in gemmology, fossil and mineral collecting and map making. Its greatest value nationally is the provision of information on which the general public can better evaluate the country's natural resources.

58. Geology Offers Great Benefits to the Average Person

Sprigg R.C. (1969), Some Exciting Possibilities for Australian Earth Science Courses, ASTJ, 15,2, 11-15 (August)

Synopsis

A lengthy argument is presented by a geology enthusiast for the great benefits to be gained by the average person and by society generally of a broader knowledge of the nature of the earth and of the processes which shape it.

Discussion

In contrast with its teaching a decade or so ago, geology is becoming a much more dynamic subject. If excitement can be aroused in young people by the wealth of new discoveries being made about our earth, some reduction could occur in the tendencies to boredom and reliance upon potted entertainment resulting from increasing leisure and general affluence. Examples are given of new discoveries in the earth sciences which materially affect individuals and society and of the new techniques through which such discoveries have been made. Reference is also made to the areas in earth science to which one or more of biology, chemistry and physics make important contributions.

In earth science courses, the average student should be led to an appreciation of the extent to which industry and resources development generally rely on greater knowledge of the earth and of earth processes. From a declining mineral discovering rate a decade or so ago, Australia is now in the forefront of world discovery with its possession of signigicant fractions of the world's reserves of oil, iron ore, bauxite, rutile-zircon and other minerals. A school course, in which these 'blessings of nature' are contrasted with earlier beliefs of mineral poverty, must provide stimulating fare for the thoughtful student.

59. Geology, the Citizen and the Environmental Crisis

Pratt, Brother Columbanus (1969), Earth Science: Teacher, Student and Methods, ASTJ, 15,2 17-22 (August)

This paper has little to say about the content of earth science courses, except by implication. The aspects of earth science education treated are: teachers, their desired qualifications and characteristics; pupils, predominantly living in urban environments; resource materials for teaching purposes; and recommended activities for classroom, laboratory and field.

The voice of a well-educated, interested community should be raised when political decisions affecting the well-being of society are being made. From the study of earth science students should be aware of the ir lications of large-scale mining ventures, of beach sand operations, c arry sites, of air and water pollution risks, and of other activit-i fecting the environment.

60. *Arousing Interest and Enjoyment in School Physics.*

Reimann A.L. (1955), The Teaching of Physics I
ASTJ, 1,2,3-4 & 8 (August), II 1,3, 13-15 (November)

Synopsis

The study of physics can be made interesting, stimulating and enjoyable, even in the face of difficulties such as over-full syllabuses, by various means including consolidation through various ways and correlation with other material.

Discussion

The advance of science with its ever-increasing ground to be covered has led to high-pressure cramming with a loss of interest, stimulus and enjoyment by pupils. In place of the haphazard methods of the past we must employ educative processes which combine the utmost economy with the maximum effectiveness of mental effort. Factors favouring maximum retention of material studied are interest, consolidation and correlation with other material.

Historical Approach to the Gravitation Law

As an example of the mental stimulus of interest and curiosity which can be engendered in pupils an indirect approach to the treatment of the gravitation law is described at some length. The approach is historical, beginning with the work of Tycho Brahe and Kepler, with use being made of a sequence of questions which call for mental activity, including mathematical reasoning in a constructive manner, on the part of the pupil. Essential information about the solar system, a little of the excitement of discovery of the original workers and an insight into the spirit and nature of scientific research are some of the real benefits of such an approach.

Consolidation and Correlation

Consolidation of knowledge otherwise learnt is fostered through laboratory exercises .... whose main objective, however, is the training of the mind in desirable qualities, numerical problems, graphical interpretation, essay writing and lecturette preparation.

Correlation of related topics, widely over the whole field of physics and outside it, will serve to correct the unfortunate tendency for subjects and parts of subjects to be regarded and taught as if they existed in watertight compartments. Means of effecting such correlation or integration are illustrated by reference to a bar magnet and a current carrying circuit and to the relationship between an ordinary camera and other optical instruments.

61. *Why Magnetism Should be Included in General Science Courses.*

Gardiner E.D. (1958), Magnetism in a General Science Course, ASTJ, 4,3, 70-72 (November)

Synopsis

Magnetism should be included in introductory general science courses (the author is referring to Victoria in particular) partly to provide a satisfactory foundation for later specialised study and partly because of its intrinsic interest and its extensive use in today's world.

Discussion

It is recommended that historical legends, discoveries and anecdotes should be woven into the descriptive and experimental treatment of magnets and magnetism to add interest to the treatment of syllabus topics. In the article the history of magnetism is treated at some length beginning with the legendary account of the use in 2637 B.C. of a primitive magnet by Hoang-li, the founder of the Chinese Empire, in enabling him to capture a rebellious prince. Later the first great systematic work of Gilbert in the 16th century is outlined before mention is made of Oersted and Arago in the last century. Reference is also made to the use of magnetism in exploration and navigation and to the wide variety of modern instruments and devices in which magnetism plays a key role.

62. *ANZAAS Symposium Considers Reforms in School Physics.*

Rechter B. (1962), Symposium on Physics Teaching, being portion of ANZAAS Congress in Brisbane report, ASTJ, 8,1, 49-51 (May)

The problems of physics teaching was the subject of one of the symposia held during the 35th Congress of ANZAAS in Brisbane in May 1961. The chief points of curriculum interest made were:

1. physics is a necessary element in the education of all young people,

2. school physics in general has changed little in fifty years,

3. the laws of physics should not be treated in isolation but within a general framework, and

4. the interconnections between the different branches of the subject should be stressed.

Professor Webster, of the University of Queensland, gave a report on the international conference on the teaching of physics held in Paris in 1960 under the auspices of UNESCO. This conference resolved that the subject is an essential part of the education of all adolescents, a new idea which could only be sustained if physics is considered a cultural rather than a technical discipline. The work of the PSSC in America in developing a new approach to school physics was regarded as a welcome sign of change.

Professor Butler, University of Sydney, used an approach to the teaching of the principle of moments as an example of the need to place the laws of physics within a general framework. In a similar way the concept of atom and molecule, introduced early, can produce a simple understanding of pressure and temperature and show that the latter is not unconnected with mechanics.

No conclusion was reached in the seminar on whether the emphasis on interest in the elementary stages of physics, as in Professor Butler's School, is compatible with a fundamental training in the principles of physics.

CURRICULUM DEVELOPMENT: MOVES FOR NATIONAL BODY

63. *Australian Science Curriculum Development Body Recommended*

Gardiner E.D. (1962), CONASTA XI - President's Summary
ASTJ, 8,2, 55-57 (August)

(Abstractor's note. Because the resolution adopted at the Eleventh Annual Conference of the Australian Science Teachers' Association on the theme 'The Changes we are Making in our Pupils' may, and probably did, have some influence on the setting up of the Australian Science Education Project (ASEP) by the Federal and State governments in 1969, Mr Gardiner's statements on the Conference proceedings are quoted verbatim).

"The aims of science education received considerable attention, and the statement (of the Conference decisions) sets out in some detail the changes and developments we hope to make in our pupil's attitudes, in knowledge and understanding, and in practical and manipulative skills. There is a general concern about the need for better syllabuses which will enhance our prospects of achieving our aims and for the development of methods of assessment which will not nullify our objectives. The services of experts in both science and education, on a full-time basis, are required for this task. Regarding this as a problem which can be dealt with only on a national basis, and bearing in mind the scattered nature of our population, it was therefore decided to recommend that 'An Australian Educational Foundation should be established to foster the development of integrated science courses by a national group of representatives of all those interested in science education'."

64. *The Benefits to School Science of a National Curriculum Body*

Bishop M. (1962), Science Teaching in the Future,
ASTJ, 8,3, 4-12 (November)

Synopsis

Amongst the wide-ranging aspects of school science education discussed in this paper is that of syllabus construction. The traditional method in which a part-time representative committee does a patch-work job of adding topics to, and discarding topics from, the previous syllabus is outlined. If the Commonwealth Government were to establish an Australian Educational Fund, it could be used to meet the cost of developing Australia-wide science curriculum materials employing the new massive approach of the Physical Science Study Committee in America.

Science teachers should inform educational administrators and the community that only through such an approach can satisfactory materials result.

Discussion

What school science will be like some day

Science, some day, will be presented to all school pupils from modern syllabuses, in well designed and adequately equipped science blocks, by adequately prepared teachers, employing the most efficient methods. Such teaching of science will be expensive hence, before it can be taught in this way, the value of science must be more widely accepted by the community.

The purpose of the recent 'New Deal for Science' Conference was to 'reveal the shocking and complete inadequacy of the science teaching in our secondary schools'. The Conference failed to recommend realistic solutions to the problems inherent in syllabus construction. This was because science teachers had not seen their problems in perspective with other educational problems and were much too willing to let others initiate a search for solutions.

The present unsatisfactory method of syllabus construction

Science syllabus construction as practised was then outlined. A committee of .... a university lecturer, an assortment of teachers representing bodies of one kind or another, and perhaps a departmental inspector, who may effectively and unwittingly restrict the contributions made by departmental teachers .... meets for a few hours about once a month. Consensus is reached, after discussion which may be centred on the time thought necessary to teach the topic properly, as to which particular topics should be included and which omitted. Despite the willingness and devotion of committee members this is not a satisfactory method of preparing science syllabuses for 1962.

A national curriculum development body is needed

Criticism has been levelled recently at the Commonwealth Government for its inadequate role in primary and secondary education. It appears, to the author, that if the Commonwealth were to establish an Australian Educational Fund it could be used to foster the development of nationwide syllabuses and syllabus resource materials. Only a national approach will meet the needs of science education in this country without wasting vast sums of money. Brief mention is then made of the new method of developing science curriculum materials used by the Physical Science Study Committee in America. The educational administrators and the community in Australia should be informed by science teachers of the necessity of this kind of massive attack, combining the ideas of teachers, scholars and other specialists, on curriculum development including the marshalling of appropriate resource materials.

65. *Moves Towards an Australian Science Education Foundation*

Australian Science Teachers' Association (1964), The Needs of Science Education in Australia, ASTJ, 10,1, 41-42 (May)

Synopsis

Only those parts, dealing with science curricula and the establishment of a national body to improve the teaching of science in Australia, of a statement prepared by the Australian Science Teachers' Association and considered by the Council meeting of ANZAAS in 1964 are summarised here.

Discussion

The Australian Science Teachers' Association, having considered at its three most recent annual conferences a number of aspects of science education in Australian schools, believes that now is the time to make known the more important needs. At the Conference in Melbourne in 1962 the recommendation was made that a national body be established to foster the development of science and mathematics courses for primary and secondary schools. Such developing and testing would be a costly undertaking, necessitating the financial help that can come only from such a foundation. The courses would be made available for adoption or adaptation by any state. Some correspondence between the courses in different states would be beneficial but uniformity would be undesirable.

While improvements in science education will undoubtedly result from the continuation of different kinds of activities within each State, there are certain major improvements that can only eventuate through efforts co-ordinated at the national level. The Association, therefore, asks the ANZAAS Council and its members to promote the establishment of an Australian Science Education Foundation, similar in nature and purpose to the National Science Foundation in the USA and the Nuffield Foundation School Science Project in the UK.

The report of that portion of the ANZAAS Council meeting proceedings concerned with the Association's submission and request is the subject of the next item - Digest 66.

66. *ANZAAS Council Supports Australian Science Education Foundation*

Stanhope R.W. (1964), Report of the Proceedings of the ANZAAS Council Meeting, ASTJ, 10,1, 43-45 (May)

Synopsis

After presentation in January 1964 of the Australian Science Teachers' Association case for the establishment of an Australian Science Education Foundation to develop school science curriculum materials, the Council of ANZAAS recommended that the ANZAAS General Committee should promote the early establishment of such a foundation.

Discussion

The Need for a National Science Curriculum Development Body

Of the several important factors contributing to the unsatisfactory situation in secondary school science education, mentioned by Stanhope* in his address to the Council, one concerned science curricula. It was 'the wasteful use of human and material resources resulting from the duplication of effort in syllabus writing'. A real and serious need exists for these major problems to be attacked on a Federal scale, hence the Australian Science Teachers' Association advocates strongly the establishment of an Australian Science Education Foundation. Such a body, widely representative of interested and informed groups, would acquire such status that its pronouncements and advice would command attention at the highest levels.

Funding a National Curriculum Body

Examples were then given of existing bodies in the United Kingdom and the United States which exercise some of the functions proposed for the Australian Foundation, of the science curriculum projects they support, and of the large sums of money provided by these overseas bodies for such projects. It is suggested that probably more benefit would accrue to school science teaching generally if a small proportion of the £5,000,000 granted annually by the Federal Government for science laboratories was diverted to the Foundation's use. Mention was then made of possible sources, governmental and non-governmental, of financial support for the Foundation; of the work-force and office facilities that would be needed; and of possible locations for its headquarters.

*Mr Stanhope was one of the three representatives of the Australian Science Teachers' Association on the ANZAAS Council and the mover, on behalf of the Association, of the two motions mentioned later in the report.

The Motion Passed by the ANZAAS Council

Two motions were then proposed, enthusiastically supported, and carried without dissent. The first was, in effect, that the Council recommends that the General Committee of ANZAAS should promote the early establishment of such a foundation, and the second that the Council was in sympathy with the Association's submission and requested that the General Committee give urgent consideration to the matter.

It was reported later that the General Committee had given favorable consideration to the motion (the first of those mentioned above) and that suitable action should follow.

67. *A Case for National Syllabuses for Secondary School Courses*

Bassett G.W. (1965), Towards a National System of Australian Education, ASTJ, 11,2, 9-15 (August)

Only the last, short portion of this edited version of an address by Professor Bassett at the Fourteenth Conference of the Australian Science Teachers' Association held in Brisbane in May 1965 dealt directly with the restricted area of education covered in this series of digests. Because of its brevity, this portion of the address as published is quoted verbatim.

"There is, I believe, a strong case for national syllabuses which are created by the most expert people in the country. Good syllabuses do not reduce the need of the teacher to act in a fully professional manner while teaching them. They are set out in such a way that the objectives of the course and the relations of these aims to the particular concepts and methods of the subject are made clear. Such syllabuses are a major contribution to educational thinking; they are not just a collection of topics. The freedom of individual teachers around the country would not be threatened by them. On the contrary, they would be a stimulus and challenge to them to ensure that the values of the subject being taught are secured."

See also Digest 68.

68. *Against a Standard Australian Science Syllabus*

Squire R.A. (1966), Standard Science Syllabus for Australia, ASTJ, 12,3, 77-78 (November)

Synopsis

In this letter to the editor of the journal arguments are advanced against the suggestion that Australia should adopt uniform syllabuses in secondary school science.

Discussion

The argument in favour of uniformity in syllabuses that students transferring interstate would not then encounter syllabus changes is dismissed as being frivolous since probably less than 5% would be involved. Again, while admitting that standard syllabuses would possibly be more economical, the writer implies that flexibility and freedom from regimentation are more important than cost saving.

The remainder of the letter is devoted to statements of reasons why uniform syllabuses for the whole of Australia should not be adopted. The substance of these are: (i) a uniform syllabus would be difficult to change; (ii) interstate competition, a most healthy enterprise, would be stifled; (iii) syllabus preparation would be by permanently-appointed theorists out of touch with the classroom situation; (iv) difficulty would be experienced by (new) university professors who wished to institute changes at the matriculation level; (v) State research centres and individual schools would lose any incentive to try out new ideas; (vi) uniformity in syllabuses is not the accepted policy in the USA, in Canada, and in the UK; and (vii) modification of a standard syllabus for different regions, which the advocates of uniformity say is possible, would suit nobody while trying to suit everybody.

See also Digest 67.

69. *Federal Minister's Support of Curriculum Revision Projects*

Bisset I.J.W. (1967), Opening Address .... CONASTA XVI, ASTJ, 13,3, 27-30 (November)

Synopsis

Bisset, Assistant Secretary in the Commonwealth Department of Education and Science, referred firstly to the financial support provided by the Commonwealth Government for school science facilities and secondly to the curriculum development efforts of science teachers themselves. He then stated that his Minister was prepared to seek monetary support from the Government for curriculum revision projects in science and other subjects if two or more States agreed to co-operate.

Discussion

Much of this address was devoted to statements of the considerable sums of money which the Federal Government has provided or plans to provide for the construction and equipping of science laboratories and for the building of new teachers' colleges or the expansion of existing ones. While proper science facilities and good science teachers are of undoubted importance, it is essential for successful teaching that the science curriculum be up to date, showing how developments in science have had practical application resulting in improvement in our social and material wellbeing. Reference is made to the efforts of science teachers themselves in the revision of curricula as evidenced by the Nuffield Project, the Australian Biological Science Curriculum Study, and the Victorian Junior Secondary Science Project.

It was reported that the Minister for Education and Science was willing to approach his parliamentary colleagues for the support of curriculum revision projects in science or in other subjects provided more than one of the State Education Departments agree upon a common approach to a problem. The Minister was not thinking about a completely centralised educational system as the objective of such an exercise.

See also Digests 71 and 72.

70. Australia's Need of a Full-time Curriculum Development Body

Van Praagh G. (1969), Need for Curriculum Development in Australia in 'Letter to the Editor', ASTJ, 15,1, 35-37 (May)

Synopsis

Van Praagh, a member of the Nuffield Chemistry teaching project team, mentioned that during his eight-week Australian visit he had formed the opinion that Britain and Australia were experiencing the same kinds of difficulties in science teaching. He advocated that a full-time curriculum development body be set up. The present concern of Australian science teachers about curricula and recent British developments in this area were discussed.

Discussion

The author, one of the headquarters' team of the Nuffield Chemistry teaching project, had gained the impression that the same difficulties that had been experienced in school science teaching in Britain are being encountered here - how to make it modern and relevant and yet allow pupils time to acquire a real understanding of the subjects. Attempts to solve the problem have been, as yet, unsuccessful. The early establishment in Australia of some full-time body concerned with curriculum development, working closely with teachers, seems to be most desirable if we are to produce good scientists for the future and citizens with some understanding of what science is about.

While the author's visit was to publicise the Nuffield projects, he gained some impressions about Australian science teaching.

1. The concern of groups in each state about syllabuses and the considerable interest shown in the Nuffield and American work.

2. The over-full syllabuses are worrying British and Australian teachers. While the latter wish to remedy the situation they have insufficient influence on course construction despite representation on syllabus committees.

3. The considerable activity in curriculum reform takes different form in different states. The Commonwealth Government is offering financial help to States prepared to combine their efforts.

After mentioning that British experiences are similar to Australian, comments were made on the above topics and recent developments in Britain outlined.

1. Consultative committees, not advisory bodies, of university scientists, experienced teachers and others greatly assisted the Nuffield teams. While courses at any educational level should cater primarily for those who are leaving, they should also provide a suitable springboard for the next stage.

2. The Nuffield project has extended its original O-level work to all the other levels of school science from primary to sixth form. Any new course for a particular age range should be co-ordinated with preceding and succeeding courses, something not evidenced in the work of syllabus committees in some States.

Other matters discussed in this letter were: material facilities, the drift of senior pupils from science, the teacher shortage, and science teachers' centres.

71. Federal Government Will Consider Supporting Curriculum Projects.

Bowen N. (1970), Excerpt from the Opening Address, ASEP Guidelines Conference, 18 February 1970, ASTJ, 16,1,110 (May)

The following remarks were made by the Hon. Nigel Bowen, the then Commonwealth Minister for Education and Science,

"What I am suggesting is that a major curriculum revision is only likely to be successful if it is undertaken on a broad scale. The present Prime Minister recognised this when, as Minister for Education and Science, he offered Commonwealth Government involvement in curriculum development. The States, of course, are primarly responsible for their own efforts in this field, but the Commonwealth Government did feel that there were likely to be opportunities for efforts beyond the resources of the single State. It is therefore prepared to consider proposals and remains prepared to consider proposals for curriculum development projects, provided they are put forward by two or more States. A second aspect here is that there are obvious national economies in a co-operative project in which all or several States might participate, pooling knowledge and skills."

See also Digests 69 and 72.

72. The Commonwealth and Curriculum Projects in Chemistry and Biology

Bowen N.H. (1970), School Curriculum Proposals, ASTJ, 16,2,81 (August)

The Hon. N.H. Bowen, Minister for Education and Science .... as reported in Hansard, House of Representatives, 9 April 1970, stated in addressing the House:

"The Commonwealth is having discussions with the States on curriculum development proposals relating to the social science and to woolclassing. There have also been discussions with interested persons on curriculum proposals in the fields of chemistry, mathematics and human biology".

See also Digests 69 and 71.

ON NEW AND EMERGING CURRICULA

73. Alternatives in Curriculum Decision Making

Cohen D. (1971), Curriculum Development in the Sciences, ASTJ, 17,3,7-14 (October)

Synopsis

This paper was one of several contributions to the special theme, 'Curriculum Development' of the October 1971 issue of the Australian Science Teachers' Journal, of which Cohen is the Editor.

With the emergence in Australia of a large measure of curriculum autonomy, particularly at the junior secondary school level, teachers are now free to develop curricula better suited to the needs of their pupils. Accompanying this freedom are responsibilities for sound decision making concerning objectives, learning experiences and evaluation. The author discussed the different alternatives in each of these areas. The quality of curriculum implementation is likely to be improved as teachers become involved in considering these alternatives and choosing from them.

Discussion

The selection of learning experiences (including content), if a good job has been done in specifying the objectives, is governed by the teacher's decisions on a number of issues. These include the emphasis placed on understanding of contemporary scientific problems such as pollution and lunar exploration; the degree of concern about teaching specific knowledge, for example about energy; and whether or not the content is to be integrated.

If, on the other hand, the teacher had opted not to start with the specification of objectives, then the content selected will be the 'knowledege of most worth' of which the author gives some examples from traditional courses. One of the greatest problems arising from the historically narrow approach to curriculum development is that the curriculum committee's function has been merely to specify science content which, for a variety of reasons, differs only in small detail from earlier curricula. An important implication of the vastness of scientific information and of its exponentially expanding rate of accumulation is that there is no 'one correct' or even 'one preferable' set of content for school science courses for all.

Reference is made to the use of the major generalisations or concepts of the sciences by workers in the USA and in Victoria in the organisation and selection of subject matter for new curricula; it being assumed, of course, that the teachability of the material will be assessed in classroom trials.

In his conclusion to that portion of the paper concerning content selection Cohen, who declares himself to be somewhat 'process-oriented' opts for an initial, clear statement of process objectives followed by the selection of such content as will best promote the attainment of the objectives. It has been recommended that children's interests should figure prominently in the selection and sequencing of curriculum content. However, in view of the uncertainty as to the nature and stability of child interests, perhaps meaningfulness to students is the most important criterion to be applied in determining sequence.

74. *The Accountability of Teachers for Curriculum Decisions*

Thomas I.D. (1973), The Editor's Page, ASTJ, 19,4,4 (December)

Synopsis

Curriculum decision making should involve many groups of people, including teachers because they, mainly, translate the decisions into actions. Are teachers prepared to accept responsibility for making these decisions and to be held accountable for them?

Discussion

Curriculum decisions affect the needs, aspirations and expectations of many groups of people, who, therefore, should each have some say in the decision-making process. These groups and the reasons for their involvement are listed. Amongst the groups are teachers because they are largely responsible for translating the decisions into actions.

Curriculum decisions are now largely being made by teachers. This is their professional responsibility, which their training should enable them to discharge. Too often, however, groups of teachers or individuals want to make the decisions without being accountable for them.

Three things are clearly required of those who would make these decisions. Firstly, they are responsible for determining the needs, aspirations and expectations of all those likely to be affected by the consequences of the decisions. Secondly, the needs, etc. have to be reflected in realistic and practical programs in schools. Lastly, the decision makers are to be accountable for their decisions. Are we, as teachers, prepared to accept the responsibilities of making curriculum decisions?

75. *Piaget's Theories in School Science Teaching*

Tisher R.P. (1963), Some Implications of Piaget's Theories for Science Teaching, ASTJ, 9,1, 9-12 (May)

Synopsis

Piaget's work shows that each individual passes sequentially from childhood to adolescence through three stages of mental development - the 'pre-operational', the 'concrete'. and the 'formal'. Each stage is characterised by certain identifiable mental operations of which the child is capable. Piaget's studies and their replication by the author in pilot researches in New South Wales and by overseas workers have great significance for secondary school science teachers. During the concrete stage, which reaches its completed form by about the age of 13 years in New South Wales, pupils may be expected to have the mental equipment to cope with certain kinds of science content and activities. Examples of these from a range of sciences are given and similarly of those better deferred to the formal stage which is completed by about 16 or 17 years of age. Piaget's views, still the subject of some controversy, need exhaustive testing in an Australian setting and, if confirmed, translation into educational practice.

Discussion

The Challenging Features of Piaget's Work

At a given age, an individual's thought, writes Piaget, is limited to the nature of the 'structure', i.e. the group of allied operations which the individual can bring to bear on a problem. These operations indicate the type of concepts a child may acquire at a given age; this is the challenging feature of Piaget's theories. As Piaget has recently stressed, the emergence of a particular stage of mental development cannot be tied to an average age; it varies considerably with social environment and even more with social culture. To some writers, mental rather than chronological age is the more applicable.

Implication of Piaget's Theories for Science Teaching

The concrete and the formal stages are of special relevance to secondary school science teaching. The author's studies with New South Wales children suggest that the concrete stage, entered at about 8 years of age, is completed at about 13 and the formal probably at about 16 or 17. Examples are given of the kinds of mental operations which children in each of these stages can perform and, in consequence, the kinds of subject matter and activities that can be handled satisfactorily.

The Concrete Stage

If Piaget's theories are accepted, then, in the early secondary school years (the concrete stage) pupils should have abundant opportunities to examine new chemicals and biological and geological specimens and to perform experiments individually. Classification of materials, analysis into constituent parts and arranging a series in order are examples of what should follow. While in this stage pupils should not be expected to propose and systematically test hypotheses.

The Formal Stage

In the formal stage of mental development, but not before, the student is able to deal with proportional relationships such as moments, flotation of bodies in liquids, Boyle's Law, valency, molecular formulae, chemical calculations, and so on. Piaget's theories also appear to suggest that unifying themes and major generalisations in science should not be discussed extensively until the later secondary school years.

Tasks for the Future

Much controversy has followed publication of Piaget's ideas and his theories are not understood completely, although some important features of his work have been confirmed. Important tasks for the future are the extensive testing of his theories in an Australian setting and their translation into classroom practice.

76. *American vs Australian Courses* *Integration When? How?*

Anon. (1965), A Summary of Conclusions Reached by CONASTA XIV Discussion Groups, ASTJ, 11,3, 63-66 (November)

Because this article is itself a summary, those portions concerned with the subject matter of this series of digests are quoted verbatim.

"New Trends in Science Courses

A. Are our Courses Necessarily Inferior to American Products?

All groups were of the opinion that the preparation of Australian courses was inadequate. Particular inadequacies listed were:

(i) in the time taken to prepare a course,
(ii) the lack of testing of a course before its introduction,
(iii) the lack of money to finance the thorough preparation of a course.

Nevertheless, most groups felt that in spite of these inadequacies, Australian courses need not be inferior to overseas courses; and that overseas courses should be very carefully studied before adoption or adaptation by an Australian school authority.

B. Can an American Course be Adopted without Major Changes?

Yes, provided that the aims of the American course were substantially the same as those of the Australian course it would replace. But many members pointed out that:

1. Many American courses are very different from our traditional courses, and

2. American courses are designed for a very different situation, educational and social.

In particular, it was felt that many changes would be needed in adopting American courses in biology, stratigraphy (part of geology), and astronomy.

E. Can Integration of Scientific Knowledge be Successfully Accomplished before the end of Secondary School?

No definite answer was given to the question. It was considered that inter-relationships should be emphasised wherever possible. If integration of scientific knowledge is possible, it cannot be achieved by a student without deliberate guidance by the teacher."

77. Traditional and Modern Curriculum Development Procedures Contrasted

Stanhope, Roy W. (1965), A Revolution in Science Curriculum Construction, ASTJ, 11,2, 17-22 (August)

Synopsis

Courses which are relevant to the pupils are amongst the five essentials for satisfactory science teaching in schools. A relevant course is one which is based on modern science content, is teachable and learnable, and has clearly stated and attainable objectives. A modern curriculum development program is described using the new American Earth Science Curriculum Project as an example. The marked contrast between this kind of approach and that used typically in Australia is emphasised. The method of implementing an American-style science curriculum development project in Australia is indicated. It is suggested that more benefit would accrue to Australian school science education if some of the Federal funds now being devoted to the provision of science blocks alone were diverted to financing a scientific approach to science curriculum construction.

Discussion

The paper begins with the contrast between the development through repeated trials of a new medicine for humans and the untrialled introduction of new science courses in Australia.

Amongst the five essentials for satisfactory science teaching in schools, pride of place is given to the provision of courses which are relevant to the pupils,the meaning of relevant being given.

The Modern Method of Curriculum Development

A somewhat detailed description is then furnished of a scientific method of preparing not only a course or syllabus but the simultaneous development of a curriculum and its inseparables: pupils' books, teachers' guides, and a range of auxiliary materials. The particular curriculum project used in illustration is the Earth Science Curriculum Project (ESCP), the most recent of the several American efforts aimed at reforming school science education and one of several such projects with which the author had personal experience in 1964.

Contrasts between Australian and American Procedures

Some marked contrasts are then drawn between the activities involved in this American program and that of a typical Australian effort. The latter was that which produced the syllabus materials for the new 'Science' course introduced in New South Wales in 1962 following the adoption of the Wyndham secondary education reorganisation plan. The contrasts, shown in tabular form, are between the number of persons involved, the time devoted to the writing stages, the length of the development period and the presence or absence (in the case of New South Wales) of classroom trials. The contrasts would be more validly based if the number of people involved and the time they spent in writing the textbook and the teacher's manual for the New South Wales course were also taken into account. The textbook occupied the full-time work of some 40 persons for a period of about 6 weeks and the manual about 25 for 3 or 4 weeks.

The Feasibility of Using in Australia the American Procedures

The adoption of an American-style science curriculum development program in Australia is quite feasible. It would require full-time personnel engaging in writing materials, and rewriting after classroom trials, for 6 or 8 weeks in 3 or 4 successive summers; the establishment of a number of test centres where project staff members and trial teachers from nearby schools could confer weekly; trials of materials with pupils representative of the appropriate school population; and finance, massive by Australian standards.

The Funding of a Modern Approach in Australia

The costs of completing such a program could be met by diverting to the project some of the money now being provided by the Commonwealth Government wholly for building and equipping school science laboratories. It is considered that greater benefit would accrue to science teaching overall if this action was taken instead of providing just buildings and equipment.

78. The Junior Secondary Science Project's Unique Approach

Dale L.G. (1966), An Australian Innovation in Science Curriculum Construction, ASTJ, 12,3, 43-46 (November)

Synopsis

In 1966 the Junior Secondary Science Project commenced the development of curriculum materials for the four-year General Science course in Victoria. It is the first Australian attempt to prepare such materials using the procedures followed in recent American and British projects. The background to the project, its inauguration, the individual-pupil approach adopted, and the plans proposed for trial and evaluation of the experimental materials are stated. Trials of the first drafts of some of the Form I units are proceeding in a number of Victorian schools and in other States. The establishment of the project might well mark an interim step towards co-operation between all the States in the preparation of materials flexible enough to enable adaptation to any State course of study.

Discussion

Australian science educators have recently shown much interest in the new American and British Nuffield science curriculum projects, many having obtained first-hand information during visits to the headquarters of the projects. The efforts of these and of other people to improve Australian science curricula have led to the incorporation into new syllabuses of many of the overseas ideas on suitable subject matter. The nett result, however, has been disappointing so far, because the subject committees have had to work on a very limited time schedule.

Initiation of the JSSP Plan

The Science Standing Committee of the Victorian Universities and Schools Examination Board at a meeting late in 1963 initiated the establishment of the 'Junior Secondary Science Project' to produce new curriculum materials for the 'Science' course extending over the four years of junior secondary schooling in Victoria. The initial planning envisaged developmental procedures similar to those used in the new overseas projects, including the incorporation into the overall syllabus plan of the important ideas in each subject area as furnished by specialists in the discipline.

The JSSP Materials

Directed jointly by the Science Standing Committee and the Australian Council for Educational Research operations began in February 1966 with a full-time executive officer and two half-time writers. An individual-pupil approach based on a class set of cards, booklets, and associated materials has been adopted in preference to a textbo . The subject matter has been organised in units, each written around a topic or an important idea and each designed to occupy about four weeks of class time. An annotated list of the kinds of concrete materials furnished with each unit is given . What is considered to be an essential part of the project is that all material should be tried in classes, rewritten on the basis of this initial trial, retried in its revised form and again rewritten before being published for general distribution. Additional feedback is being obtained during classroom visits by the project staff.

Some of the proposed Form I units have been produced, a few of them trialled in Victorian schools and others are in various stages of a first draft. Materials so far produced have been sent to the State Directors of Education and to others, while class sets have been sent to a few schools outside Victoria. Under-estimation of the work involved has led to staffing and financial problems but it is expected that these will be overcome.

Towards a National Science Curriculum Project

Reference is made by the author to the advocacy by Bassett (see Digest 67) and Stanhope (see Digest 77) at CONASTA XIV a year ago that science curricula should be developed on a national scale. While the Junior Secondary Science Project cannot be regarded as a national one, it opens up possibilities that could well be exploited as a first step towards national unity in the teaching of junior secondary science. The approach adopted is flexible enough to enable adaptation of the material to any State course of study, hence the question of agreement on a common syllabus does not necessarily arise.

Interstate Co-operation of Unit Writers Sought

Victoria's resources are limited in the supply of both writers and finance. The first of these would be overcome by the secondment of writers from other States who could be involved in the preparation of units suited to their own State's needs. In this way the pressure on the Victoria team would be lessened and all writers could prepare additional needed supplementary materials. The Australian Science Teachers' Association may well provide the motivation for this beneficial co-operation between the States.

See also Digest 79.

79. *The Junior Secondary Science Project - Recent Progress*

Australian Council for Educational Research (1967), Junior Secondary Science Project - A Progress Report, ASTJ, 13,1, 71-73 (May)

This report, prepared in February 1967, is virtually a condensation of that published* three months earlier with some additional information.

This information concerns plans for production activities during 1967 and the difficulty in recruiting writers and readers willing to comment critically on the written drafts. The problem of obtaining adequate finance for the maintenance of the project and, in particular, for the production of supplementary printed and visual materials, has yet to be solved. Increased interest in the project has been shown outside Victoria; during 1967 trials will be held in Papua-New Guinea, South Australia and Tasmania, and, possibly, in other States.

See also Digest 78.

*Dale L.G. (1966), An Australian Innovation in Science Curriculum Construction, ASTJ, 12,3, 43-46 (November). See Digest 78.

80. A Case for a Grade 1-Grade 12 Science Program

Bovell R.R. (1967), The Influence of Primary School Science, ASTJ, 13,3, 33-41 (November)

Synopsis

The past influence of primary school science on secondary courses and recent developments in primary science and mathematics are discussed. Next is presented a case for the development of sequential science programs from Grade 1 to the end of secondary education with no discontinuity when transfer occurs from primary to secondary schools. Individual differences should be recognised and students should be allowed to proceed through such courses at variable rates. Support is sought in solving some of the problems associated with the implementation of these suggestions.

Discussion

Primary Science: Past and Present

Until recently, Australian primary school science has been little other than nature study. This fact, together with a limited time allocation, no provision usually for orderly sequence of topics from grade to grade, and inadequately prepared and supported teachers has meant that primary science has provided nothing of significance on which secondary science courses could be built.

Within the last ten years science has assumed a new importance at all educational levels. The need for scientific manpower, for more scientifically literate citizens, and for coping with the explosion of scientific knowledge has led to three reactions. These are the pruning of dead wood from existing courses, a shift in emphasis on objectives and content, and a tendency for an earlier start by improving primary school science teaching.

Reference is made to recent moves in some States to replace nature study courses by science courses with emphasis on physical science, a long neglected area. Some features of two new American primary school science curricula being currently tried in Western Australia and of the Nuffield Junior Science Project are described briefly.

Primary-Secondary Science Sequential Program Needed

Research published in Scotland in 1963 showed that, for various reasons, the transition from primary to secondary education should extend from age 10 to age 13. This implies that there should be a gradual progress from one level to the other in science. The National

Science Teachers' Association of the United States advocates that the science curriculum should be planned on a K-12 basis at least.

With reform in science curricula at the secondary level preceding that at the primary level, some topics in the new primary courses are also found in the new secondary courses. First priority should be given to devising a sequential program for Grades K to 12 which avoids such repetition and builds cumulatively on the previous science experiences of children. Factors which need to be considered in developing such a program are listed.

Catering for Individual Differences in a Sequential Program

Attention is then given to a scheme catering for individual differences being used in some Western Australian primary schools. A given course is divided into units, each representing about a term's work for average students, but less or more for below average and above average pupils respectively. Such a unit organisation, continuous through primary and secondary schooling, seems appropriate for teaching a sequential K-12 science course.

Problems of implementing these reform proposals in primary schools are finally briefly discussed.

81. *The Australian Science Education Project: Meeting the Guidelines*

Ramsey G.A. and Dale L.G. (1971), The Australian Science Education Project: Its Rationale, ASTJ, 17,3, 51-57 (October)

Synopsis

The co-operating governments of the six States and of the Commonwealth funding the project have laid down a number of guiding principles. For each guideline stated in the paper, an account is given as to how the project has met or plans to meet it. The relevant matters discussed include the science content; its organisation; current trends in junior secondary science; and individual differences in intellectual development, reading ability and interests. The present status of the project and its special features conclude the paper.

Discussion

Guideline One: Grades 7 to 10

This guideline directed the project to produce materials sufficient in range and quantity to satisfy a majority of the requirements of Australian science courses in Grades 7 to 10. While the answer to 'what science?' did not seem to be a distillate from existing State syllabuses, the materials produced would need to be useful in serving such syllabuses. In answering the question 'Why teach science?', ASEP believes that science and its methods provide an important and special way of interpreting the environment and could assist in the intellectual, social and emotional development of children. The organisation of the materials is based on the belief that science and its processes are interesting to the child in that they provide novel and unusual experiences which are meaningful to him when they provide a useful way of making sense of his environment. The exploration of the environment using the processes of science would foster the establishment of the mental structures necessary to accommodate new experiences. Examples are given showing how the materials are designed to reflect a five-point environmental scheme ranging from the exploration of himself as an individual to that of the natural environment.

Integration of the sciences, as generally attempted in Australian junior courses, usually appears artificial with the component sciences remaining clearly visible in the syllabus statements. However, with ASEP's emphasis on exploring the environment, unification of the sciences occurs naturally.

Guideline Two: Science Teaching Trends

This guideline called on the project to take into account similarities and differences in the present and projected pattern of science education in all States. The most important trend, apart from integration, is the greater freedom given all Australian teachers to determine their own courses. To encourage and assist this trend it was decided to produce a large pool of units, each complete in itself and with little inter-unit linkage, from which teachers could select those considered most suitable on a number of grounds including a school's particular environment. The organisation is loose enough to allow a course to be made up using as few or as many units as desired, perhaps interspersed with or in conjunction with non-ASEP materials; such situations being made possible by the clear statement that 'none of the States will prescribe the materials for use in schools'.

Initially the production goal was about 70 units, thus allowing a reasonable selection ratio since a four-year course would need a maximum of about 36 units. Unfortunately, due to inflation, only about 42 seem likely to eventuate.

Guideline Three: Individual Differences

Since two of the three major differences influencing the enterprise, states of intellectual development and reading level of pupils, are not so much related to content but to approach, method, expression, vocabulary, etc., no digest is being made of the authors' discussion of these differences nor of that of Guideline Four: Teacher Decisions.

The third major individual difference, that of interests, is catered for by providing in most units a core, occupying about one quarter of the total unit time, and up to twelve options, of which the average pupil may do only the three or four which interest him most.

ASEP Features

The project has the following pleasing features:

1. it is 'made in Australia', a matter of importance in these days when a large proportion of Australian schools are using American-produced materials;

2. it is producing a team of people with experience, unequalled previously in Australia, in curriculum development and evaluation;

3. it is fostering interstate co-operation on a wide scale;

4. it is influencing the nature of supplementary materials produced by commercial, industrial, and other bodies; and

5. it is providing a well-documented account of an experiment in curriculum development of value for future planning in education.

82. The New Fifth Form Biology Course in Victoria

Macaulay D.F. (1955), New Trend in Teaching of Biology, ASTJ, 1,3, 2-3 (November)

Synopsis

A completely new approach in the teaching of Leaving Certificate (5th secondary school year) biology in Victoria is outlined. Emphasis is on major principles and their application to society's important problems.

Discussion

In keeping with new ideas on the teaching of modern science in Great Britain and USA, the amended syllabus emphasises major biological principles and their application to important problems in modern society. In this new course, biology is no longer regarded as being divided into three separate and distinct sciences - biology, zoology, and physiology, with their emphasis upon the memorisation of countless, often unrelated, facts. The Living Organism, Metabolism, and Self-Perpetuation are the three sections, which, with their listed subdivisions, provide the structural pattern of the course. It is designed to meet the requirements of a cultural subject and to be sufficiently complete within itself to satisfy the educational needs at this particular (school) level.

Indications are given of the subject matter treatment of the broad areas: Man and His Health, Food and Agriculture, and Ecology. Through consideration of major problems in these areas the scope of the subject is widened and it is brought down to levels that can be clearly related to everyday living.

83. Recent Developments in School Chemistry, Mainly in South Australia

Chittleborough G. (1964), Chemical Education in Secondary Schools, ASTJ, 10,3, 62-69 (November)

Synopsis

In this review of the present situation and of desirable future changes in the teaching of secondary school chemistry in South Australia reference is made to new and proposed developments in chemistry courses in certain of the Australian States. The recommendation is made for the establishment of a 'Chemical Education Committee' to promote the interests of chemical education in South Australia.

Discussion

Developments in some States

In reporting on recent progress and modern developments in school chemical education, reference is made to the existence in Victoria of a Standing Committee in Chemistry which looks after the interests of chemical education in secondary schools. In January last, a sub-committee was given the task of creating curriculum materials for a new matriculation course in chemistry for 1966. A significant new advance in syllabus construction in Australia was the full-time secondment of two people and the relief from teaching duties of university members to complete the undertaking. In New South Wales an independent Chemical Education Committee has as its present principal responsibility that of preparing a chemistry syllabus for the last two years of secondary schooling.

In South Australia two new developments are attracting wide attention. In the first place, the new Intermediate science course to be introduced in 1967 will be a two-unit course completely replacing the existing chemistry and physics courses. It is to comprise inter-related chemistry, physics, biology and geology in the approximate proportions 3:3:3:1. Included in the chemistry section are materials on atomic structure and valence, bonding, and ionic reactions - all hitherto not met until the present Leaving chemistry course. Secondly, the new university matriculation requirements will call for the design of modern fourth and fifth year chemistry courses. However, it seems that the new matriculation syllabus is to serve only as a stop-gap measure until chemistry is replaced at the Intermediate level by the new science course.

South Australia's Special Needs

A special need in South Australian chemical education is the provision of a terminal course at the fourth year, the pre-matriculation level. Up to the present non-matriculating students have had available to them only the comparatively narrow course designed for prospective university entrants. Such a terminal course should help prepare the average student for life in today's scientific world in which chemistry plays a vital role. Pupils' interest would be maintained by presenting basic modern principles and their applications in the domestic, agricultural, medical and industrial spheres.

While the Australian Science Education Foundation, as proposed by the Australian Science Teachers' Association, would, if and when established, have the responsibility of improving school science education on a national scale, there exists a need for a special committee with prime and vital interest in chemical education in South Australia. The functions which such a Chemical Education Committee could perform are then listed.

84. *Victoria Trialling New Fifth Form Chemistry Course*

Puddephatt R.F. (1971), New Form V Chemistry Course on Trial in Victoria, ASTJ, 17,4 113-114 (December)

Synopsis

A new chemistry course for Grade 11 is being trialled in some thirty Victorian secondary schools. It consists of two terms of CORE CHEMISTRY, as set out in the examination board's syllabus, followed by one term of options. The general opinion of the trial teachers is that the CORE content is a little excessive and that the depth of treatment in some topics is too great for the average student. Since the HSC (Matriculation) examination determines the content of the Grade 12 course, the viability of an OPTION scheme could be in question.

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