SCIENCE AND THE SECONDARY CURRICULUM.

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Mr. A. E. Cawthorne, an English Science teacher, recently published a book entitled "Science in Education", and dedicated the publication "to the child, who is fast becoming the last concern in secondary education".

This dedication was probably meant to be thought-provocative, and to those interested in secondary education it presents a very definite challenge.

If we as Science teachers take up this challenge we are immediately confronted with many questions; for example, what is the function of Science in the secondary curriculum? Does our present curriculum allow Science to fulfil this function?

I am aware that many issues concerning the place of Science in secondary education, and the methods of teaching Science, are controversial, and mere matters of opinion, but that does not render them less important, or, for that matter, less interesting.

Now, what is the function of Science in the secondary curriculum? Many claims concerning it have been made and most of them with some justification.

It is generally supposed that a Science course is valuable to the child because of (1) its discipline, (2) its content, (3) its cultural value.

Its discipline is emphasised because (*a*) it quickens and cultivates powers of observation, (*b*) it develops ability to classify observed facts, (*c*) it develops resourcefulness and initiative, (*d*) it teaches the pupil to reason from observed facts and to reason causally.

Its content is emphasised because (*a*) it provides the pupil with valuable information concerning the physical universe and himself, (*b*) it introduces him to some of the greatest thinkers of the ages.

Its cultural value is emphasised because it tends to develop in the child an open mind, and provides him with material for a sound philosophical background.

I think this is a fair statement of the part that Science may play in the curriculum.

It is generally agreed that Science is not the only subject that can confer these benefits, but in some ways, apart from its content, Science does hold a unique position in any curriculum. It is unique because it brings the pupil into direct contact with material things themselves and offers him an opportunity to profit by his own experience directly, and not only by the experience of others. In this way it acts as a psychological corrective in the school life of the child.

It is contended by many, and with well-supported arguments, that the Science courses in our secondary schools tend to be too informative, and that the methods in general use are far from being scientific. In other words they say that too much stress is being placed on the content, and not enough on the disciplinary and cultural aspects of the subject. In fact, much the same criticism is being levelled at almost every subject in the curriculum.

This may be due to the fact that we live in an age of specialisation. In their enthusiasm, the advocates for each subject have attempted to emphasise the importance of that subject by increasing its subject matter; and the point of view of the pupil, who is trying to cope with seven or eight subjects, has been quite disregarded.

Now, is such criticism justified? Is due emphasis placed on the disciplinary and cultural values of Science?

There are times, especially during the last term of the year, when one feels that the examination is the chief aim of both pupil and teacher. In Science subjects, where we should expect to find freedom and versatility, we find constraint and uniformity.

This is not in the best interests of the pupils, the teachers, or the community.

Moreover, this state of affairs has not been brought about by design, but has developed contrary to the wishes of those most interested. Assuredly it is not the desire of the Education Department or of the Board of Examiners that such a condition should arise.

The reasons for this state of affairs appear to be: (*a*) the syllabus is too ambitious to be dealt with satisfactorily in the time allotted to Sciences in most secondary schools, (*b*) the classes on the whole are far too large, (*c*) the examination papers tend to be similar from year to year, (*d*) there is a tendency to assess the ability both of teachers and of pupils on examination results.

Let us look at each of these in turn.

By saying that the syllabus is too ambitious I mean that the subject matter cannot be dealt with adequately in the allotted time by any scientific method. The syllabus may be covered, but that is a different matter. To illustrate, let us consider a typical approach to the Physics course. On arriving at school at the beginning of first year the pupils have some ideas about the quantities, length, area, volume, time, and a fixed idea about mass under the title "weight", an idea which in general is never eradicated.

After persuading the pupils to accept the usual standards, and practical units, and allowing some exercises in the measurement of lengths, areas and volumes, the teacher prepares the class for the measurement of mass. At once operations are handicapped by the size of the class—three or four to a balance—and as practical physics occurs once a fortnight a considerable time must elapse before all pupils have been able to use a balance.

However, one must not delay, so the class proceeds to the measurement of densities of solids and liquids. Experiments on pressure in liquids may follow, leading to the statement of simple pressure laws, and Archimedes' principle.

In many cases generalisations are made after two or three experiments. This is not scientific method.

One of the natural tendencies of the mind is to over-generalise. Scientific method will tend to correct not to develop such a tendency. Wonder is often expressed because pupils in the senior years are satisfied with one or two readings in experimental determinations. What else can we expect?

Whether teachers incline to the heuristic, historical, or biographical method, all will admit the value to the pupil of scientific procedure, *i.e.,* bringing to any problem an open mind prepared to investigate it impartially for one's self. It is contended by some that the actual discovery of half a dozen principles, from a series of individual experiments, in a course, is of more value in the development of the child's mind than ten times that number of principles imparted to him by a teacher. This may be an over-statement of the fact, but there is no denying that it contains a germ of truth. All are well aware of the difficulties met with in teaching a science, for not only are new facts and principles presented, but a new vocabulary has to be acquired. Moreover, it is generally agreed that it is impossible to place the pupil in the position of the original investigator. However this does not warrant unscientific procedure, it only calls for modification. Unless each problem is attacked as an investigation the discipline peculiar to the practice of Science is lost. A principle such as that of Archimedes should be formulated only after several experiments with a variety of solids and liquids.

Without more ado, it may be asserted that the amount of work to be covered obviates any but superficial experimental treatment.

In the senior classes, in what way do theory lessons in Science differ fundamentally in method from those, say, in history? They consist in general in the discussion of unobserved facts. There are many sections included in the courses which admit of little or no experimental treatment, and others that do not receive the experimental treatment they deserve because of lack of time. Apparently the time allotted to Science should be increased or the subject matter reduced, or both.

It may be urged that a teacher need not attempt to deal with all the subject matter in the syllabus, but while there are competitive examinations many will attempt the whole course even at the expense of method.

Let us briefly consider the size of the classes. Large classes are obviously a handicap. For satisfactory practical work classes in the lower school should not exceed twenty-four, and in the senior classes eighteen pupils. Individual attention of an adequate nature cannot be given if classes exceed these numbers.

Similarity in the type of questions in examination papers permits of abuse. Cramming is an inevitable result, and work not bearing on typical examination questions tends to be neglected.

There is a tendency to overrate the importance of examinations as a gauge to measure the ability of pupils and teachers.

In the first place the examinations do not satisfactorily grade the candidates, *e.g.*, as many as eighty per cent. of classes have obtained A passes in Elementary

Science at the Intermediate. To the general public these pupils appear equal in ability while the teacher of the class knows such to be far from the truth.

Again, the stressing of results causes cramming, open and unashamed. For example, since definitions and laws figure largely in the examination papers, pupils are encouraged to learn these parrot fashion.

In fact, the definitions can be reproduced with equal facility as can quotations from Shakespeare, and in many cases, I might add, with equal lack of appreciation on the part of the pupil.

The introduction of the pupil to the various quantities should be in as strictly logical an order as possible. In general a boy who depends on his memory for a definition does not know what he is talking about. Definitions and methods of dealing with typical problems can be crammed while the more fundamental things, such as understanding of the principles and facts, are neglected as not wanted by examiners. The fact that a pupil can solve a numerical problem does not mean that he grasps the underlying principle.

From what has been said about the value of examination results in the case of the pupils, the absurdity of assessing the ability of the teacher on examination results is obvious, since good results may conceivably be obtained by sacrificing the disciplinary and cultural aspects of the subject.

Now who are they that require so much work should be covered in the secondary school course? It cannot be the University, for a student may do any Science subject at the University without having done any previous work in that subject. There is no demand on the part of the general public; and with regard to the Public Service, the Science subjects are, judged by the allotment of marks, of less importance than such subjects as Ancient History, Greek, Latin, Mechanics, and almost every other subject in the curriculum.

Knowledge crammed is not culture, for culture consists in an attitude of mind, and not in an accumulation of facts.

Indeed, it is hard to find anyone who does require that so much should be attempted. It might be of interest to note here that the Science syllabus for our secondary schools was compiled originally, much in its present form, about twenty-five years ago, and was based largely on the syllabus in Scotch schools, which was itself experimental. The quantity and arrangement of the subject matter was tentative and not meant to have the air of finality with which it is now invested.

It is becoming more and more apparent that too much in quantity and not enough in quality is being required of our boys and girls, and if we are trying to develop wise and responsible citizens this procedure must surely fail.

From a psychological point of view the value of Science cannot be over-estimated. Consider the school day of the average pupil: Mathematics, Latin, English, History, French, Mathematics, Science. For five or six lesson periods the student is trying to assimilate facts as presented in text-books or on blackboards. Few of these facts are a part of the child's personal experience. In History, Mathematics and other lessons, attempts are made at analysis and logical interpretation of data, but such data appears abstract and unreal in comparison with the facts gleaned in the laboratory from actual experiment with material things. As far as his schooling is concerned the pupil looks to Science to provide the tonic and corrective for his mind. Nothing can displace Science in this function, and if the pupil does not in the Science Room develop the ability to observe accurately, to weigh evidence, and to interpret it correctly, he is not likely to do so elsewhere.

For centuries classical traditions have held a strangle-hold on education; and when we consider what little the classics offer in the way of truth regarding man and the universe we are amazed.

Language was evolved primarily for the expression and communication of ideas. If people lack fundamental ideas, facility and artistry in the use of language is of little account.

Apart from any metaphysical considerations man has a very real and wonderful existence in a very real and wonderful universe. One would think that education would at least help man to understand something of himself and this universe. Strange to say, little or no attempt is made to do this. Whereas, apart from his own language and literature, one would expect the sciences, both biological and physical, to occupy the most important place in the curriculum, we find a little room made grudgingly for a rather academic and fragmentary course. It is often suggested that sciences produce a materialistic outlook. On the contrary most great scientists have been renowned for their idealism and philanthropy.

Science but reveals from the atom to the stars a more wonderful and inspiring universe than any poet ever conceived.

Why should we hold to a pseudoculture which is largely nothing but the handing on of the fables of the past? Bearing in mind that knowledge has increased so rapidly in the last century and has so revolutionised the life of the community, some attempt should be made to put man in command of as much scientific knowledge as possible, so that we may confidently expect further advance in the future.

In these days when the knowledge of civilisation is so carefully recorded and indexed in books, it should not be our aim to overtax the memory of the pupil with a vast array of facts, rather we should strive to give him the key to such wealth.

No doubt you can all call to mind the case of students who, after gaining a formidable leaving certificate have failed to excel at the university, simply because they have never learned the art of study, the true use of books and experiments. They have depended for five years on digests of work, too skilfully prepared for them by teachers over-zealous for results. Nothing can be more devastating to real mental development than excessive memorising. It really plays on the weakness of the pupil and instead of overcoming mental inertia fosters it; *e.g.*, children will readily memorise methods of solving typical problems rather than strive to acquire confidence in attacking any problem from first principles. It is wrong for the teacher to countenance such methods let alone exploit them. There are too many people in this world just bristling with facts; but thinkers are still all too rare. In all branches of knowledge it is astonishing what the statistician can do. The history of science abounds in classical examples of people who possessed crucial facts but failed to realize their significance. Unless we help the child to recognise clearly the true meaning of facts presented to him, how can we believe that he will ever be able to explain new ones that come his way?

Now I would like to suggest that in drawing up a syllabus the first consideration should be the child and the average child at that, due emphasis being placed on all aspects of Science teaching and not on any one in particular, and bearing in mind that the average child is being trained for life and not for a university course. This would involve the cutting down of the present syllabus, to enable the treatment of each subject to be really scientific. Honours courses should be deleted for, with few exceptions, honours work in one subject means failure or poor work in another. It is much better that a child should have a balanced schooling.

Science teachers should strive earnestly for at least twelve periods per week for Science, in all secondary schools, so that Science could be given its due place in the curriculum. This would enable three sciences to be taken to the present standard. It is unfortunate that girls and boys should spend five years on any Science course without at any time using a microscope. Students always evince great interest on viewing such things as the fossil remains of foraminifera, or the aquatic feats of an amœba. Will anyone say that such interest is of less value than the mental coma induced in large numbers of non-mathematically minded students on hearing of the oxidizing actions of potassium bichromate, or of the relation of the thermal coefficients of gases?

Why should so much interesting matter be omitted and so much of little interest and value to the average student be included?

ATMOSPHERIC ELECTRICITY.

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It is very difficult to tell even a little about electricity in our atmosphere without telling a lot, because many pieces of information fit in together to form a complete picture of what is taking place. A few definitions and explanations will help.

Lightning is an electrical spark—an electric discharge—between two portions of a thunder cloud, between two clouds, or between cloud and earth. When we talk about "earth", we mean not only the ground