



Presidential Address: Technical Education and Its Relation to Science and Literature

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PRESIDENTIAL ADDRESS.

BY A. N. WHITEHEAD, F.R.S.

TECHNICAL EDUCATION AND ITS RELATION TO SCIENCE
AND LITERATURE.

THE subject of this address is Technical Education. I wish to examine its essential nature and also its relation to a liberal education. Such an enquiry may help us to realise the conditions for the successful working of a national system of technical training. It is also a very burning question among mathematical teachers ; for mathematics is included in most technical courses.

Now it is unpractical to plunge into such a discussion without forming in our minds the best ideal result towards which we desire to work, however modestly we may frame our hopes as to the result which in the near future is likely to be achieved.

People are shy of formulated ideals ; and accordingly we find formulation of the ideal state of mankind placed by a modern dramatist * in the mouth of a mad priest. "In my dreams it is a country where the State is the Church and the Church the people : three in one and one in three. It is a commonwealth in which work is play and play is life : three in one and one in three. It is a temple in which the priest is the worshipper and the worshipper the worshipped : three in one and one in three. It is a godhead in which all life is human and all humanity divine : three in one and one in three. It is, in short, the dream of a madman."

Now the part of this speech to which I would direct attention is embodied in the phrase, 'It is a commonwealth in which work is play, and play is life.' This is the ideal of technical education.

It sounds very mystical when we confront it with the actual facts, the toiling millions, tired, discontented, mentally indifferent, and then the employers—I am not undertaking a social analysis, but I shall carry you with me when I admit that the present facts of society are a long way off this ideal. Furthermore, we are agreed that an employer who conducted his workshop on the principle that 'work should be play,' would be ruined in a week.

The curse that has been laid on humanity, in fable and in fact, is that by the sweat of its brow shall it live. But reason and moral intuition have seen in this curse the foundation for advance. The early Benedictine monks rejoiced in their labours, because they were thereby made fellow-workers with Christ. Stripped of its theological trappings, the essential idea remains, that work should be transfused by intellectual and moral vision, and thereby turned into a joy, triumphing over its weariness and its pain.

* Bernard Shaw, cf. *John Bull's Other Island*.

Each of us will restate this abstract formulation in a more concrete shape in accordance with his private outlook. State it how you like, so long as you do not lose the main point in your details. However you phrase it, it remains the sole real hope of toiling humanity ; and it is in the hands of technical teachers and of those who control their spheres of activity, so to mould the nation that daily it may pass to its labours in the spirit of the monks of old.

The immediate need of the nation is a large supply of skilled efficient workmen, of men with inventive genius, and of employers alert in the development of new ideas. Another essential condition is industrial peace.

There is only one way to obtain these admirable results. It is by producing workmen, men of science, and employers who enjoy their work. View the matter practically, in the light of our knowledge of average human nature. Is it likely that a tired, bored workman, however skilful his hands, will produce a large output of first-class work ? He will limit his production and be an adept at evading inspection ; he will be slow in adapting himself to new methods ; he will be a focus of discontent, full of impractical revolutionary ideas, controlled by no sympathetic apprehension of the real working of trade conditions. If, in the troubled times which may be before us, you wish appreciably to increase the chance of some savage upheaval, introduce widespread technical education and ignore the Benedictine ideal. Society will then get what it deserves. Again, inventive genius requires pleasurable mental activity as a condition for its vigorous exercise. 'Necessity is the mother of invention' is a silly proverb. 'Necessity is the mother of futile dodges' is much nearer to the truth. The basis of the growth of modern invention is science, and science is almost wholly the outgrowth of pleasurable intellectual curiosity.

The third class are the employers, who are to be enterprising. Now it should be observed that it is the successful employers who are the important people to get at, the men with business connections all over the world, men who are already rich. No doubt there will always be a continuous process of rise and fall of businesses. But it is futile to expect flourishing trade, if in the mass the successful businesses are suffering from atrophy. Now if the successful men conceive their businesses as merely indifferent means for acquiring other disconnected opportunities of life, they have no spur to alertness. They are already doing very well, the mere momentum of their business engagements will carry them on for their time. They are not at all likely to bother themselves with the doubtful chances of new methods. Their real soul is in the other side of their life. Desire for money will produce hardfistedness and no enterprise. There is much more hope for humanity from manufacturers who enjoy their work than from those who continue in irksome business with the object of founding hospitals.

Finally, there can be no prospect of industrial peace so long as masters and men in the mass conceive themselves as engaged in a soul-less operation of extracting money from the public. Enlarged views of the work performed and of communal service thereby rendered can be the only basis on which to found sympathetic co-operation.

The conclusion to be drawn from this discussion is that, alike for masters and for men, a technical or technological education which is to have any chance of satisfying the practical needs of the nation must be conceived in a liberal spirit as a real intellectual enlightenment as to principles applied and the services rendered. In such an education geometry and poetry are as essential as turning-lathes.

The mythical figure of Plato may stand for modern liberal education as does that of St. Benedict for technical education. We need not entangle ourselves in the qualifications necessary for a balanced representation of the actual thoughts of the actual men. They are used here as symbolic figures typical of antithetical notions. We consider Plato in the light of the type of culture he now inspires. In its essence a liberal education is an education for thought and for æsthetic appreciation. It proceeds by imparting a knowledge of the masterpieces of thought, of imaginative literature, and of art. The action which it contemplates is command. It is an aristocratic education, implying leisure. This Platonic ideal has rendered imperishable services to European civilisation. It has encouraged art, it has fostered that spirit of disinterested curiosity which is the origin of science, it has maintained the dignity of mind in the face of material force, a dignity which claims freedom of thought. Plato did not, like St. Benedict, bother himself to be a fellow worker with his slaves; but he must rank with Benedict among the emancipators of mankind. His type of culture is the peculiar inspiration of the liberal aristocrat, the class from which Europe derives what ordered liberty it now possesses. For centuries, from Pope Nicholas V. to the schools of the Jesuits, and from the Jesuits to the modern headmasters of English schools, this educational ideal has had the strenuous support of the clergy.

For certain people it is a very good education. It suits their type of mind and the circumstances amid which their life is passed. But more has been claimed for it than this. It has been represented as the ideal education, and every curriculum has been judged adequate or defective according to its approximation to this sole type.

The essence of the type is a large discursive knowledge of the best literature. The ideal product of the type is the man who is acquainted with the best that has been written. Such a man will have acquired the chief languages, he will have considered the histories of the rise and fall of nations, the varied poetic expression of human feeling, and have read the great dramas and novels.

He will also be well grounded in the chief philosophies, and have attentively read those philosophic authors who are distinguished for lucidity of style.

It is obvious that, except at the close of a long life, he will not have much time for anything else, if any approximation is to be made to the fulfilment of this programme. One is reminded of the calculation in a dialogue of Lucian that before a man could be justified in practising any one of the current ethical systems, he should have spent 150 years in examining their credentials.

Such ideals are not for human beings. What is meant by a liberal culture is nothing so ambitious as a full acquaintance with the varied literary expression of civilized mankind from Asia to Europe, and from Europe to America. A small selection only is required, but then, as we are told, it is a selection of the very best. I have my doubts of a selection which includes Xenophon and omits Confucius, but then I have read neither in the original.

The ambitious programme of a liberal education really shrinks to a study of some fragments of literature, included in a couple of important languages.

But the expression of the human spirit is not confined to literature. There are the other arts and there are the sciences. Also education must pass beyond the passive reception of the ideas of others. Powers of initiative must be strengthened. Unfortunately, initiative does not mean just one acquirement. There is initiative in thought, initiative in action, and the imaginative initiative of art; and these three categories require many subdivisions.

The field for acquirement is large, and the individual so fleeting and so fragmentary. Classical scholars, scientists, headmasters, are all equally ignoramuses.

There is a curious illusion that a more complete culture was possible when there was less to know. Surely the only gain was that it was more possible to remain unconscious of ignorance. It cannot have been a gain to Plato to have read neither Shakespeare, nor Newton, nor Darwin. The achievements of a liberal education have in recent times not been worsened. The change is, that its pretensions have been found out.

My point is that no course of study can claim any position of ideal completeness. Nor are the omitted factors of subordinate importance. The insistence in the Platonic culture on disinterested intellectual appreciation is a psychological error. Action, and the transition of events amid the inevitable bond of cause to effect, are fundamental. An education which strives to divorce intellectual or æsthetic life from these fundamental facts carries with it the decadence of civilisation. Essentially, culture should be for creative action, and its effect should be to divest labour of the associations of aimless toil. Art exists in order that we may know the deliverances of our senses as good. It heightens the sense-world.

Again, disinterested scientific curiosity is a passion for an ordered intellectual vision of the connections of events. But the goal of such curiosity is the marriage of action to thought. This essential intervention of action even in abstract science is often overlooked. No man of science wants merely to know. He acquires knowledge to appease his passion for discovery. He does not discover in order to know, he knows in order to discover. The pleasure which art and science can give to toil is the pleasure which arises from successfully directed intention. Also it is this same pleasure which is yielded to the scientist and to the artist.

The antithesis between a technical and a liberal education is fallacious. There can be no adequate technical education which is not liberal, and no liberal education which is not technical, that is, no education which does not impart both technique and intellectual vision. In simpler language, education should turn out the pupil with some things he knows well, and some things he can do well. This intimate union of practice and theory aids both. The intellect does not work best in a vacuum; the stimulation of creative impulse requires, especially in the case of a child, the quick natural transition to practice. Geometry and mechanics, followed by workshop practice, gain that reality without which mathematics is verbiage.

There are three main methods which are required in a national system of education, the literary curriculum, the scientific curriculum, the technical curriculum.

But each one of these curricula should include the other two. What I mean is that every form of education should give the pupil a technique, a science, an assortment of general ideas, an æsthetic appreciation, and that each of these sides of his training should be illuminated by the others. Lack of time, even for the most favourable pupil, makes it impossible to develop fully each curriculum. Always there must be a dominant emphasis. The most direct æsthetic training naturally falls in the technical curriculum, in those cases when the technique is that requisite for some art or artistic craft. But it is of high importance in both a literary and a scientific education.

The educational method of the literary curriculum is the study of language, that is the study of our most habitual method of conveying to others our states of mind. The technique which should be acquired is the technique of verbal expression; the science is the study of the structure of language and the analysis of the relations of language to the states of mind conveyed. Furthermore, the subtle relations of language to feeling, and the high development of the sense organs to which spoken and written words appeal, lead to keen æsthetic appreciations being aroused by the successful employment of language.

Finally the wisdom of the world is preserved in the masterpieces of linguistic composition.

This curriculum has the merit of homogeneity. All its various parts are coordinated and play into each others' hands. We can hardly be surprised that such a curriculum, when once broadly established, should have claimed the position of the sole perfect type of education.

Its defect is unduly to emphasise the importance of language. Indeed, the varied importance of verbal expression is so overwhelming, that its sober estimation is difficult. Recent generations have been witnessing the retreat of literature and of literary forms of expression from their position of unique importance in intellectual life. In order truly to become a servant and a minister of nature something more is required than literary aptitudes.

A scientific education is primarily a training in the art of observing natural phenomena and in the knowledge and deduction of laws concerning the sequence of such phenomena. But here, as in the case of a liberal education, we are met by the limitations imposed by shortness of time. There are many types of natural phenomena, and to each type there corresponds a science with its peculiar modes of observation and with its peculiar types of thought employed in the deduction of laws. A study of science in general is impossible in education, all that can be achieved is the study of two or three allied sciences. Hence the charge of narrow specialism urged against any education which is primarily scientific. It is obvious that the charge is apt to be well-founded; and it is worth considering how, within the limits of a scientific education, and to the advantage of such an education, the danger can be avoided.

Such a discussion requires the consideration of technical education. A technical education is in the main a training in the art of utilising knowledge for the manufacture of material products. Such a training emphasises manual skill, and the coordinated action of hand and eye, and judgment in the control of the process of construction. But judgment necessitates knowledge of those natural processes of which the manufacture is the utilisation. Thus somewhere in technical training, an education in scientific knowledge is required. If you minimise the scientific side, you will confine it to the scientific experts, if you maximise it you will also impart it in some measure to the men, and—what is of no less importance—to the directors and managers of businesses.

Technical education is not necessarily allied exclusively to science on its mental side. It may be an education for an artist or for apprentices to an artistic craft. In that case æsthetic appreciation will have to be cultivated in connection with it.

An evil side of the platonic culture has been its total neglect of technical education as an ingredient in the complete development of ideal human beings. This neglect has arisen from two disastrous antitheses, namely that between mind and body, and that between thought and action. I will here interject, solely to avoid criticism,

that I am well aware that the Greeks highly valued physical beauty and physical activity.

I lay it down as an educational axiom that in teaching you will come to grief as soon as you forget that your pupils have bodies. This is exactly the mistake of the post-renaissance platonic curriculum. But nature can be kept at bay by no pitchfork ; so in English education, being expelled from the class-room, she returned with a cap and bells in the form of all-conquering athleticism.

The connections between intellectual activity and the body, though diffused in every bodily feeling, are focussed in the eyes, the ears, the voice, and the hands. There is a coordination of senses and thought, and also a reciprocal reaction between brain activity and material creative activity. In this reaction the hands are peculiarly important. It is a moot point whether the human hand created the human brain, or the brain created the hand. Certainly the connection is intimate and reciprocal. Such deep-seated relations are not widely atrophied by a few hundred years of disuse in exceptional families.

The disuse of hand-craft is a contributory cause to the brain-lethargy of aristocracies, which is only mitigated by sport where the concurrent brain activity is reduced to a minimum, and the hand craft lacks subtlety. The necessity for constant writing and vocal exposition is some slight stimulus to the thought-power of the professional classes. Great readers, who exclude other activities, are not distinguished by subtlety of brain. They tend to be timid conventional thinkers. No doubt this is partly due to their excessive knowledge outrunning their powers of thought ; but partly it is due to the lack of brain-stimulus from the productive activities of hand or voice.

In estimating the importance of technical education we must rise above the exclusive association of learning with book learning. First-hand knowledge is the ultimate basis of intellectual life. To a large extent book learning conveys second-hand information, and as such can never rise to the importance of immediate practice. Our goal is to see the immediate events of our lives as instances of our general ideas. What the learned world tends to offer is one second-hand scrap of information illustrating an idea derived from another second-hand scrap of information. The second-handedness of the learned world is the secret of its mediocrity. It is tame because it has never been scared by facts. The main importance of Francis Bacon's influence does not lie in any peculiar theory of inductive reasoning which he happened to express, but in the revolt against second-hand information of which he was a leader.

The peculiar merit of a scientific education should be that it bases thought upon first-hand observation ; and the corresponding merit of a technical education is that it follows our deep natural

instinct to translate thought into manual skill, and manual activity into thought.

We are a mathematical association, and it is natural to ask 'Where do we come in?' We come in just at this point.

The thought which science evokes is logical thought. Now logic is of two kinds, the logic of discovery and the logic of the discovered.

The logic of discovery consists in the weighing of probabilities, in discarding details deemed to be irrelevant, in divining the general rules according to which events occur, and in testing hypotheses by devising suitable experiments. This is inductive logic.

The logic of the discovered is the deduction of the special events which under certain circumstances would happen in obedience to the assumed laws of nature. Thus when the laws are discovered or assumed, their utilisation entirely depends on deductive logic. Without deductive logic science would be entirely useless. It is merely a barren game to ascend from the particular to the general, unless afterwards we can reverse the process and descend from the general to the particular, ascending and descending like the angels on Jacob's ladder. When Newton had divined the law of gravitation he at once proceeded to calculate the earth's attractions on an apple at its surface and on the moon. We may note in passing that inductive logic would be impossible without deductive logic.

Now mathematics is nothing else than the more complicated parts of the art of deductive reasoning, especially where it concerns number, quantity, and space. In the teaching of science, the art of thought should be taught: namely, the art of forming clear conceptions applying to first-hand experience, the art of divining the general truths which apply, the art of testing divinations, and the art of utilising general truths by reasoning to more particular cases of some peculiar importance. Furthermore, a power of scientific exposition is necessary so that the relevant issues from a confused mass of ideas can be stated clearly, with due emphasis on important points.

By the time a science, or small group of sciences, has been taught thus amply, with due regard to the general art of thought, we have gone a long way towards correcting the specialism of science. The worst of a scientific education based, as is necessarily the case, on one or two particular branches of science, is that the teachers under the influence of the examination system are apt merely to stuff their pupils with the narrow results of those special sciences. It is essential that the generality of the method be continually brought to light and contrasted with the speciality of the particular application. A man who only knows his own science, as a routine peculiar to that science, does not even know that. He has no fertility of thought, no power of quickly seizing the bearing of alien

ideas. He will discover nothing and will be stupid in every practical application.

This exhibition of the general in the particular is extremely difficult to effect, especially in the case of younger pupils. The art of education is never easy. To surmount its difficulties, especially those of elementary education, is a task worthy of the highest genius. It is the training of human souls.

Mathematics, well taught, should be the most powerful instrument in gradually implanting this generality of idea. The essence of mathematics is perpetually to be discarding more special in favour of more general ideas, and special methods in favour of general methods. We express the conditions of a special problem in the form of an equation, but that equation will serve for a hundred other problems, scattered through diverse sciences. The general reasoning is always the powerful reasoning, because deductive cogency is the property of abstract form. There again we must be careful. We shall ruin mathematical education if we use it merely to impress general truths. The general ideas are the means of connecting particular results. After all it is the concrete special cases which are important. Thus in the handling of mathematics, in your results you cannot be too concrete, and in your methods you cannot be too general. The essential course of reasoning is to generalise what is particular and then to particularise what is general. Without generality there is no reasoning, without concreteness there is no importance.

Concreteness is the strength of technical education. I would remind you that truths which lack the highest generality are not necessarily concrete facts. For example, $x+y=y+x$ is an algebraic truth more general than $2+2=4$. But 'two and two make four' is itself a highly general proposition lacking any element of concreteness. To obtain a concrete proposition immediate intuition of a truth concerning particular objects is requisite, for example 'these two apples and those two apples together make four apples' is a concrete proposition, if you have direct perception or immediate memory of the apples.

In order to obtain the full realisation of truths as applying, and not as empty formulae, there is no alternative to technical education. Mere passive observation is not sufficient. In creation only is there vivid insight into the properties of the object produced. If you want to understand anything, make it yourself, is a sound rule. Your faculties will be alive, your thoughts gain vividness by an immediate translation into acts. Your ideas gain that reality which comes from seeing the limits of their application.

In elementary education this doctrine has long been put into practice. Young children are taught to familiarise themselves with shapes and colours by simple manual operations of cutting out and of sorting. But good though this is, it is not quite what I mean.

That is practical experience before you think, experience antecedent to thought in order to create the ideas, a very excellent discipline. But technical education should be much more than that ; it is creative experience while you think, experience which realises your thought, experience which teaches you to coordinate act and thought, experience leading you to associate thought with foresight and foresight with achievement. Technical education gives theory, and a shrewd insight as to where theory fails.

A technical education is not to be conceived as a maimed alternative to the perfect platonic culture, namely, as a defective training unfortunately made necessary by cramped conditions of life. No human being can attain to anything but fragmentary knowledge, and a fragmentary training of his capacities. There are, however, three main roads along which we can proceed with good hope of advancing towards the best balance of intellect and character, these are the way of literary culture, the way of scientific culture, the way of technical culture. No one of these methods can be exclusively followed without grave loss of intellectual activity and of character. But a mere mechanical mixture of the three curricula will produce bad results in the shape of scraps of information, never interconnected or utilised. We have already noted as one of the strong points of the traditional literary culture that all its parts are coordinated. The problem of education is to retain the dominant emphasis, whether literary, scientific, or technical, and without loss of coordination to infuse into each way of education something of the other two.

To make definite the problem of technical education fix attention on two ages, one thirteen when elementary education ends and the other seventeen when technical education ends, so far as it is comprised in a school training. These dates give four years for a technical course. I am aware that for artisans in junior technical schools a three years' course would be more usual. On the other hand, for naval officers, and for the directing classes generally a longer time can be afforded. We want to consider the principles to govern a curriculum which shall land these children at the age of seventeen in the position of having technical skill useful to the community.

Their technical manual training should start at thirteen bearing a modest proportion to the rest of their work, and should increase in each year, finally to attain to a substantial proportion. Above all things it should not be too specialised. Workshop finish and workshop dodges adapted to one particular job should be taught in the commercial workshop, and should form no essential part of the school course. A properly trained worker would pick them up in no time. In all education the main cause of failure is staleness. Technical education is doomed if we conceive it as a system for catching children young and for giving them one highly specialised

manual aptitude. The nation has need of a fluidity of labour, not merely from place to place, but also, within the reasonable limits of allied aptitudes, from one special type of work to another special type. I know that here I am on delicate ground, and I am not claiming that men while they are specialising on one sort of work should spasmodically be set to other kinds. That is a question of trade organisation with which educationalists have no concern. I am only asserting the principles that the training should be broader than the ultimate specialisation, and that the resulting power of adaptation to varying demands is advantageous to the workers, to the employers, and to the nation.

In considering the intellectual side of the curriculum we must be guided by the principle of the coordination of studies. In general, the intellectual studies most immediately related to the manual training will be some branches of science. More than one branch will, in fact, be concerned, and even if that be not the case, it is impossible to narrow down scientific study to a single thin line of thought. It is possible, however, provided that we do not press the classification too far, roughly to classify technical pursuits according to the dominant science involved. We thus find a sixfold division, namely,

(1) Geometrical techniques ; (2) Mechanical techniques ; (3) Physical techniques ; (4) Chemical techniques ; (5) Biological techniques ; (6) Techniques of Commerce and of Social Service.

By this division it is meant that, apart from auxiliary sciences, some particular science requires emphasis in the training for most occupations. We can, for example, reckon carpentry, ironmongery, and many artistic crafts among geometrical techniques. Similarly, agriculture is a biological technique. Probably cookery, if it includes food catering, would fall midway between biological, physical, and chemical sciences, though of this I am not sure.

The sciences associated with commerce and social service would be partly algebra, including arithmetic and statistics, and partly geography and history. But their section is somewhat heterogeneous in its scientific affinities. Anyhow, the exact way in which technical pursuits are classified in relation to science is a detail. The essential point is that with some thought it is possible to find scientific courses which illuminate most occupations. Furthermore, the problem is well understood, and has been brilliantly solved in many of the schools of technology and junior technical schools throughout the country.

In passing from science to literature in our review of the intellectual elements of technical education, we note that many studies hover between the two ; for example, history and geography. They are both of them very essential in education, provided that they are the right history and right geography. Also books giving descriptive accounts of the general results and trains of thought in various

sciences fall in the same category. Such books should be partly historical and partly expository of the main ideas which have finally arisen. Prof. R. A. Gregory's recent book, *Discovery*, and the Home University Library series illustrate my meaning. Their value in education depends on their quality as mental stimulants. They must not be inflated with gas on the wonders of science, and must be informed with a broad outlook.

It is unfortunate that the literary element in education has rarely been considered apart from grammatical study. The historical reason is that, when the modern platonic curriculum was being formed, Latin and Greek were the sole keys which rendered great literature accessible. But there is no necessary connection between literature and grammar. The great age of Greek literature was already past before the arrival of the grammarians of Alexandria. Of all types of men to-day existing, classical scholars are the most remote from the Greeks of the Periclean times.

Mere literary knowledge is of slight importance. The only thing that matters is how it is known. The facts related are as nothing. Literature only exists to express and develop that imaginative world which is our life, the kingdom which is within us.

It follows that the literary side of a technical education should consist in an effort to make the pupils enjoy literature. It does not matter what they know, but the enjoyment is vital. The great English Universities, under whose direct authority school children are examined in plays of Shakespeare, to the certain destruction of their enjoyment, should be prosecuted for soul-murder.

Now there are two kinds of mental enjoyment, the enjoyment of creation and the enjoyment of relaxation. They are not necessarily separated. A change of occupation may give the full tide of happiness which comes from the concurrence of both forms of pleasure.

The appreciation of literature is really creation. The written word, its music, and its associations are only the stimuli. The vision which they evoke is our own doing. No one, no genius other than our own, can make our own life live. But except for those engaged in literary occupations, literature is also a relaxation. It gives exercise to that other side which any occupation must suppress during working hours. It also has the same function in life as has literature.

To obtain the pleasure of relaxation requires no help. The pleasure is merely to cease doing. Some such pure relaxation is a necessary condition of health. Its dangers are notorious, and to the greater part of the necessary pure relaxation nature has affixed not enjoyment, but the oblivion of sleep.

Creative enjoyment is the outcome of successful effort and requires help for its initiation. Such enjoyment is necessary for high-speed work and for original achievement. To speed up production with unrefreshed workmen is a disastrous economic policy. Temporary

success will be at the expense of the nation, which for long years of their lives will have to support worn-out artisans, unemployables. Equally disastrous is the alternation of spasms of effort with periods of pure relaxation. Such periods are the seed-time of degeneration, unless rigorously curtailed. The normal recreation should be change of activity satisfying the cravings of other instincts. Games afford such activity. Their disconnection emphasises the relaxation, but their excess leaves us empty.

It is here that literature and popular art should play an essential part in a healthily organised nation. Their services to economic production would be only second to those of sleep or of food. I am not now talking of the training of an artist but of the use of art as a condition of healthy life. It is analogous to sunshine in the physical world.

When we have once rid our minds of the idea that knowledge is to be exacted, there is no special difficulty or expense involved in helping the growth of artistic enjoyment. All school-children could be sent at regular intervals to neighbouring theatres where suitable plays could be subsidised. Similarly for concerts and kinema films. Pictures are more doubtful in their popular attraction. But interesting representations of scenes or ideas which the children have read about would probably appeal. The pupils themselves should be encouraged in artistic efforts. Above all the art of reading aloud should be cultivated. The *Roger de Coverley* essays of Addison are perfect examples of readable prose.

Art and literature have not merely an indirect effect on the main energies of life. Directly, they give vision. The world spreads wide beyond the deliverances of material sense, with subtleties of reaction and with pulses of emotion. Vision is the necessary antecedent to control and to direction. In the contest of races, which in its final issues will be decided in the workshops and not on the battle-field, the victory will belong to those who are masters of stores of trained nervous energy, working under conditions favourable to growth. One such essential condition is Art.

If there had been time, there are other things which I should like to have said ; for example, to advocate the inclusion of one foreign language in all education. From direct observation I know this to be possible for artisan children. But enough has been put before you to make plain the principles with which we should undertake national education.

In conclusion, I recur to the thought of the Benedictines who saved for mankind the vanishing civilisation of the ancient world, by linking together knowledge, labour, and moral energy. Our danger is to conceive practical affairs as the kingdom of evil, in which success is only possible by the extrusion of ideal aims. I believe that such a conception is a fallacy, directly negatived by experience. In education this error takes the form of a mean

view of technical training. Our forefathers in the dark ages saved themselves by embodying high ideals in great organisations. It is our task, without servile imitation, boldly to exercise our creative energies, remembering amid discouragements that the coldest hour immediately precedes the dawn.

In response to a call from the President, Mr. P. ABBOTT gave his paper on :

THE POSITION OF MATHEMATICS IN EDUCATIONAL RECONSTRUCTION.

It would not be possible in the short time allotted to me for this paper to discuss any scheme of Educational Reconstruction which might appear to me as ideal. Indeed it is doubtful, notwithstanding the constant use which is made of the term, whether any reconstruction of our educational system, in the full sense of the word, is probable or even possible. But many reforms, some of them fundamental and far-reaching in their effects, are both possible and probable. It is with certain of these which, directly or indirectly, will materially affect the position of mathematics, that I propose to deal as far my limited time allows.

Before that is done, it is essential that we should first examine, however briefly, the fundamental causes which are tending to produce change. They are, in the main, though not entirely, the outcome of the war, which has compelled us to scrutinise our systems and methods, and to test their values from the standpoint of efficiency. Also, in view of the increasing strain upon our national resources and the depletion of our reserves of wealth, we are compelled to eliminate all forms of waste both now and after the war.

Examining our educational system from these aspects, we cannot feel satisfied that all is well with it, and hence there is a very general feeling that it must be made more efficient. The country has been impressed with the efficiency of Germany, not only from the military point of view, but also in the matters of education, science and industry. With this has also come the realisation that peace will bring with it yet another struggle, in industry and commerce, not less fierce nor less intense than the present clash of arms. For that we must make due preparation.

Moreover, the war has led the average person to realise to what an extent science, and the applications of science to engineering, electrical engineering, chemistry and the like, have permeated our modern existence. There is evidence everywhere of an increasing desire to acquire some clear knowledge of these things, and especially that the youth of the nation shall be trained to understand them. A feeling for more scientific and technical education is growing, and is finding expression, not only by the usual signs in the press, but in the number of students, surprisingly large under the circumstances, who are attending our technical schools. Let our lady members note that this movement is not confined to the male sex, for women students are beginning to make their appearance in our classes in engineering, electrical engineering, architecture and industrial chemistry. There has begun a shifting of the centre of gravity in education towards science and technology, and this cannot fail to influence the teaching of mathematics.

These are some of the currents and movements which are making for changes, and we must be prepared to take account of them if mathematics is to occupy its proper position in our educational system. We must not assume that changes which may be the outcome of these movements will mean any deterioration in our standards or any lower-