History for the Present

The Christian Brothers Technology Education Project 1985 – 1992, AI and the Commodification of Education

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Dedicated to the Memory of the late

Rev. Brother Leo Canny

Sometime Chairman of the Secondary Teacher Registration Council

and

Rev. Brother Plunkett Nolan

Sometime Principal St Mary's Christian Bothers College of Education

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Abstract: Changing patterns in the structure and content of work coupled with the increasing cost to students of higher education suggest that the structure of the curriculum, its content and the philosophy that drives it needs to be re-visited. That philosophy is utilitarian and concerned only with the economic good. As such, students are regarded as commodities rather than as persons. The economic good, prevails over personal good and social good. The argument in its favour first aired in the *Edinburgh Review* in 1809 prevailed over the literary education promoted by the University of Oxford. It replaced the idea of a place of "universal knowledge" with a place of "specialist knowledges", and promoted the sciences and technologies at the expense of the humanities. It has emphasized the "specialist mind" at the expense of the "enlarged mind", and lost the charism of community.

Organizations and society require individuals to be adaptable and flexible, and able to take up employment that is "far" from what they envisaged. Such an undertaking requires the development of an "enlarged" mind for which current arrangements of the curriculum and instruction are not well suited. The need for new models of the curriculum is apparent.

There are several models in the literature that offer a way forward. One of them was developed in the in the period 1985 to 1992 by the Christian Brothers and members of the Division of In-Service Education of the University of Dublin. A template was produced that may be applied at any level of education. Whereas in the medieval university Latin was a necessary study, in this model Engineering and Technological Literacy is the core subject. The model attempts to reconcile the personal with the social and the economic.

The purpose of this text is to discuss present day relevance of this model within the context of the two hundred year old and continuing debate about the usefulness of knowledge. It begins with a restatement of the problem in terms of the commodification of students. The two sides of the debate as presented between 1809 and 1811 and again in 1852 in Dublin, Edinburgh and Oxford are summarised. This debate is resurrected because of its relevance to the increasing costs of higher education, and the impact of AI and technology on all levels of education and work. How the curriculum should respond to these changes is discussed using the model developed for the Christian Brothers Technology Education Project.

1. The commodification of education

In 1809 the Reverend Sydney Smith in a review of a book *Essays on Professional Education* by Richard Lovel Edgeworth in the *Edinburgh Review* declared the principle of utility in education as, " the only proper criterion of every branch of education [that is] - its utility in future life." [1, 2]. This review was intended as a criticism of the classical education offered by the University of Oxford. It occasioned a debate about the purposes of university education the content of which has largely been forgotten. I shall argue that this has been to the detriment of our understanding of what a university education should be about.

The picture that we have of the present day university in the UK and Ireland is of an institution that is based on the principle of utility as expressed by the Reverend Smith but with the important substitution of "work" for "life". University education has been supported by governments because it is conceived to be an "economic good". The more people who have a higher education the better off the economy shall be. But it is a particular kind of higher education that is valued, namely the provision of courses for the production of large numbers of graduates in what are now called the STEM subjects.

The idea that the nation is short of STEM qualified people has not only persisted for very many years in the UK and Ireland but in the United States in spite of evidence that neither politicians or academics who support that view actually understand what is happening in that particular part of the world of work [3]. This view has been to the detriment of development in the humanities. A university is no longer perceived as a place of "universal knowledge". While the number and range of subjects that can be studied has increased considerably, each is a specialism without interconnection between them. Doubts have also been expressed about the relative value of some of these new degree programmes in terms of their ability to ensure high return jobs, that is, their economic usefulness [4].

Beyond that governments have not only listened to industrialists complaints about the curriculum [5] but they have also been persuaded that business models should be used by the universities to manage their resources. A rather 'ancient' model of management by objectives has been forced on the universities for this purpose. Since, it was found, and it became a selling point, that those who had obtained a university degree earnt substantially more over a life time than those without a university degree, (a difference that has come to be known as the "graduate premium"), it was argued that students should pay for their higher education by means of loans which would be repayable as soon as the

graduate obtained a specified level of annual income [6]. To put it in another way university education was an investment which should be paid for by the participant irrespective of the State's requirement for such participants. At the same time funding should be directed toward those subjects thought to have most impact on the development of the economy.

Crudely put, governments came to take a business view of students as products or commodities that have to be guided into occupations thought necessary for the economic good of the State. Society and the economy are confluent and the prevailing philosophy is utilitarian. It prevailed over the Oxford model, and coupled with the explosion of knowledge that was taking place (during the second industrial revolution), the foundation of the "university of specialisms" was laid. However, even though the context has changed, the principles that charged that nineteenth century debate remain of importance as the sections that follow will show.

2. History past-the battle of 1809 - 1811

It is not possible to enter into any great detail into the response to the Reverend Smith by Edward Copleston because his reply written in 1810 was a pamphlet 187 pages in length! We are, however indebted to the Irish Jesuit Scholar Fergal McGrath who in 1962 critiqued the debate in detail [7]. He considered that the "views of lasting significance that emerged from that debate were;

1. All education conduces to some good. This is agreed on by both.
2. This good may be the immediate improvement of the human race, either materially, intellectually or spiritually. Smith implies that this is the only good to be aimed at, and perhaps unwittingly stresses the value of material good.
3. Or it may be the training of the mind to produce such good ultimately. This is the aim stressed by Copleston.
4. Literature has a peculiar value in this training of the mind.
5. Classical literature above all others is fitted for this task" [8, p28; and for the meaning of literature 9].

McGrath in noted in his summary that, "in passing [that] there were two fundamental considerations which neither contestant thought of, or at any rate formulated: firstly, that the most essential part of intellectual training is in the realm of philosophy and theology, and secondly that it is impossible to come to any satisfactory definition of utility or of its various degrees, unless one has a definite conviction as to the whether the end of man is temporal happiness or something beyond it" [10, p33].

This remains the position today except that most people, it would appear, take a temporal view of the purpose of humanity. But, it cannot be argued that the policies of higher education promoted in the last thirty or more years have promoted the greatest amount of happiness which is the goal of utilitarianism [11]. If anything it may be argued that higher education has become more divisive as between those who have it and with alarming consequences for those who don't. For example, Nobel Laureate Angus Deaton and his wife Anne Case have within the last month reported that "while mortality rates continue to fall among all education classes in most of the rich world, middle-aged non-Hispanic whites in the US with a high school diploma or less have experienced increasing midlife mortality since the late 1990's. This is due to both rises in the number of "deaths of despair" – death by drugs , alcohol and suicide- and to a slowdown in progress against mortality from heart disease and cancer, the two largest killers of middle age" [12].

3. History past- the idea of a University 1852

1852 in this context is best known for the delivery of Blessed John Henry Newman's lectures on the foundation of the Catholic University of Ireland that were subsequently published as "*The Idea of a University*" which for some became the bible of liberal education [13]. In the seventh of the published lectures he dealt with the question of usefulness. Some critics such as Dwight Culler believed that it was to the detriment of the case that Newman made in an earlier discourse for what might be called "useless" knowledge. In my view he could hardly avoid this discussion and we are the better for it since this debate has not gone away. Newman's discourse includes extensive quotations from Copleston and Davison in support of his argument, and ends with what is probably the most quoted statement on what university teaching is all about (exhibit 1). But before that he summarises his position […] "that that training of the

intellect, which is best for the individual himself, best enables him to discharge his duties to society […] If then a practical end must be assigned to a University course, I say it is that of training good members of society" [14]. It is clear that this begins with the person who is the source of belief and behaviour.

In 1852 Sir William Hamilton who was professor of logic and meta physics at the University of Edinburgh, another critic of the Oxford system, distinguished between liberal education and professional training in a way that McGrath considers Newman would have approved. Hamilton wrote: "In the former respect, the student *is considered as an end unto himself*; his perfection, as a man simply, being the aim of his education. This is the end proposed in what is academically known as the Faculty of Arts or of Philosophy. In the latter respect, the learner *is not viewed as himself as an end*, that end being now something out of himself; for not his perfection as a man, but his dexterity as a professional man -in a word, his usefulness as an instrument, has become the aim of scientific preparation" [15].

The need to resurrect this debate is apparent for two reasons. First, the cost of higher education, and second the impact of AI and changing technology on all levels of education and work.

University training is a great ordinary means to a great ordinary end: it aims at raising the intellectual tone of society, at cultivating the public mind at purifying national taste, at supplying true principles to popular enthusiasm and fixed aims to popular aspiration at giving enlargement and sobriety to the ideas of the age, at facilitating the exercise of popular power, and refining the intercourse of private life. It is the education which gives [persons] a clear conscious view of [their] own opinions and judgements, a truth in developing them, an eloquence in expressing them; and a force in urging them. It teaches [them] to see things as they are, to go right to the point, to disentangle a skein of thought, to detect what is sophistical; and to discard what is irrelevant. It prepares [them] to fill any post with credit, and to master any subject with facility. It shows [them] how to accommodate himself to others, how to throw himself into their frame of mind, how to bring before them his own, how to influence them, how to come to an understanding with them, how to bear with them. [They] are at home in any society, [they] know when to speak and when to be silent, [they are] able to converse, [they are] able to listen, [they] can ask a question pertinently, and gain a lesson seasonably, when [they] have nothing important [themselves], [they are] ever ready, yet never in the way, [they are] a pleasant companion, and a comrade you can depend upon; [they know] when to be serious and when to trifle, and they have sure tract which enables [them] to trifle with gracefulness and to be serious with effect. [They] have the repose of mind which lives in itself, and which has resources for its happiness at home when it cannot go abroad. [They have] a gift which serves them in public and supports [them] in retirement, without which failure and disappointment have a charm. The art which tends to make a [person] all this, is the object which it pursues as useful as the art of wealth or the art of health, though it is less susceptible of method, and less tangible, less certain and complete in the result."

Exhibit 1. Extract from Newman's discourse VII on Knowledge and professional skill. (Newman, J. H. *The Idea of a University Defined and Illustrated.* 1947 edited with an introduction by C. F. Harrold. London, Longmans Green. P 157.

4. The costs of higher education

The movement to mass higher education from the 1960's was accompanied without any detailed discussion of the aims of higher education. At the same time there has been grade inflation accompanied by career deflation. By the latter is meant the backwash effect whereby employers, as for example in Ireland, who in the past would have employed students holding good Junior certificate qualifications at 15 or 16, in many instances now require Leaving Certificate qualifications from students who 17 or 18 years of age. Similarly where a Leaving Certificate would qualify for a particular job, now a degree is required. In the United States as long ago as 1990 a High School Diploma was more or less regarded as useless, and there is similar qualification inflation [16]. The result is that a degree has become an imperative.

If it is correct that higher education is in a bubble, the cost of maintaining the present structure of higher education may increase to the point where many families may not be able to afford the additional loans that their offspring will require to see them through university, and the burden will fall on those children. More and more families are likely to be affected as job structures change, and wages and salaries fail to increase at an appropriate rate. Consider the fact that in the period 1970 to the present U.S labour compensation share in net income has remained relatively constant, while real product compensation has risen dramatically (17). In the period 1990 and 2009 the price of tuition fees rose by 274% between 1990 and 2009 which was more than the price of any basket of goods or services (18).

The net effect in the US is to drive a division between those who can afford loans and those who cannot really afford loans. Sara Goldrick-Rab describes the average net increase in the price of college education for the top 75 percent of the socioeconomic spectrum as moderate. Contrast that with the bottom quartile of the population have seen a rise from 44.6% of their income in 1990 to 84% today (19). Nothing could be more divisive.

However, Beth Akers and Mathew Chingos argue that more accurate pictures are needed of how loans are affecting different sectors of the population. Their inquiries led them to believe that there was no systemic loan crisis [20] But, the matter is more complicated than it seems as a recent British study shows. For whatever reason, it shows that students from poorer families are likely to earn less over a lifetime by about 10% at the median [21] than students from more wealthy families. There are also considerable differences in re-numeration between subjects studied and institution attended. However, neither of these reports null the proposition that there will be a crisis if there is little or no economic growth and incomes do not rise proportionally, and/ or there are significant structural changes in the workforce.

5. The changing structure of work and education

The so-called rise of populism in Europe and the United States exposed deep seated problems in the structure of work. Globalism saw the displacement of jobs from mature industrial countries to countries in the developing world where labour is much cheaper. Similarly, in the UK it is believed by many workers that jobs have been lost in agriculture and construction to employees from Eastern Europe who are willing to accept lower wages. At the same time it became clear that in some industries, in particular the motor vehicle industry, robots were replacing workers. While this had been understood for many years the impact of technology on jobs is only just becoming to be appreciated. One study has estimated that 47% of total U.S employment is in the high risk category, jobs that is, that could be expected to be automated relatively soon. [22]. There has been no dearth of newspaper and magazine articles on the topic during the last year [23].

It is important to remember that the substitution of labour by technology is a function of the relative costs. If the technology is too expensive, a substitution will not be made. Some argue that some jobs will be safe because the costs of substitution will be too great.

Somethings are clear. First, to date the digitisation and automation of tasks has primarily affected unskilled, low skilled workers, and low wage occupations [24]. Second, AI is beginning to impact on the jobs of the lower middle and professional classes. The Susskind's, Father and Son, conclude that "increasingly capable, non-thinking machines will displace much of the work of human professionals" [25]. There is no shortage of writers who believe that the role of the teacher, especially the role of the teacher in higher education will be transformed [26].

Third, it is by no means clear what will happen in the future. Some believe, that as has happened since the end of World-War II, new jobs will arise as old jobs are lost to automation. This optimistic position seems to be held by many politicians [27]. A less generous scenario is that technology will be disruptive of jobs and that for some time there will be job losses before the system eventually pulls out of the dip. Some R and D is focussed on how to combine humans and computers to best achieve some tasks, and some authors are very cheerful about the possibilities [28; 29].

Looked at from the perspective of the positive value we place on work, the "pessimistic" forecast suggests that "an increasing number of professionals must be absorbed in a decreasing range of types of task (namely, those in which professionals still have the advantage). In short , it will become ever more difficult, as time passes and machines become increasingly capable, to ensure that there is enough reasonably-paid employment for professionals" [30, p 290]. The Susskind's who made this prediction were very clear that they were, "not predicting that the professions will disappear over the next few years. We are looking decades ahead […] and anticipating an incremental transformation and not an overnight revolution" [31, p291]. While this may appear to be sanguine, it is their contention that we have to begin to consider the choices we will have to make now.

Of considerable significance for the curriculum is the Susskind's belief that tasks that require the making or supporting of important moral decisions "are unlikely to be passed over to a machine".

Fourth, many professionals in pursuit of their careers have made several work changes during their lives. In the future, however, they may be forced to take a change of direction because of redundancy. At the same time many companies may prefer to recruit younger people because they are thought to be more creative, and are cheaper to employ. This means that professional workers will have to be more adaptable and flexible than they have been in the past which promotes the question, "does the present education system prepare them for such a future?"

There seems to be common ground between the various reports as to what is required from the education system in terms of the skills it should develop. The authors of *Information Technology and the U.S. Workforce* drew attention to the fact that employers want both domain knowledge (things one knows) and specific skills (things one knows how to do) [p 108, 32). They go on to say that "it is unrealistic to assume that all members of the U.S. populace should be able to interchangeably attend any model of educational institution and receive interchangeably robust experience to attain broad knowledge, a vast array of specific skills, and fluid access to any element of the workforce." They went on to emphasize three areas of capability that educational institutions should attend to *viz* "(1) general adaptability as evidenced by critical thinking and flexibility of learning approach, (2) capacity for lifelong learning and, […] social skills" (p 109-110).

Inspection of earlier reports in the U.S [33], and U.K [34], suggest that the abilities to think in terms of systems and to synthesize are key skills. While the inclusion of the social or interpersonal skills dimension is one that is repeated in other reports, there is no evidence that the "personal" is considered to be important. Summarisng the views of the Scottish philosopher John Macmurray on education Costello writes, "Education [...] must aim to serve both realities at once but with a vision that situates the functional, social goal (learning skills and aptitudes) as a subordinate dimension within the cultural one (personal formation and development in community). These are not two separate kinds of education but two aspects of the same education process [...]. It is impossible to teach any technical growth whatever without producing some cultural effect. Equally it is impossible to enhance expression without stimulating growth in technical competence. But the latter should be integrated within the former and directed to its service. In other words, every growth in technical know-how should be taught in the context of responsibility - to people and to our culture" [35], and I would add to ourselves.

In terms of the thesis offered here, it provides for the reconciliation of the personal and professional identities.

How then should the curriculum and structure of the education system respond?

6. The curriculum

The 1809 debate caused a debate about the relative merits of what was called a literary education on the one hand, and on the other hand education for usefulness. "Literary" as conceived then was akin to a general education. This debate is alive and well. A strong argument exists that without the kind of education described by Sir William Hamilton the skill of transfer will not be acquired without difficulty. By transfer is meant the ability to bring the knowledge that we have to the solution of previously unseen problems. For convenience the transfer that takes place within subjects may be called "vertical" given that new learning is acquired, and there is an addition to the stock of procedural and tacit knowledge. Engineering educators would claim that that is the purpose of the engineering curriculum. It should be noted that even within a subject transfer may be difficult.

Consider now the problem that is created when a person has to make a complete change of job. This requires an ability to learn within a new situation which may be much more difficult. For convenience I call this "horizontal" transfer since the person concerned has to move to areas of thought and activity where the usefulness of his or her procedural and tacit knowledge may not be readily apparent.

Adaptability is characterised by the ease with which a person can transfer knowledge and skill within and across disciplines. Ease of adaptability is a quality of an enlarged mind. It arises from a person's ability to think and reason. It is these abilities applied across a range of subjects that enlarge the mind. The one thing in which we are all engaged is reasoning. We are all engaged in "deducing well or ill, conclusions from premises, each concerning the subject of his own particular business"- "The man who has learnt to think, and to reason and to compare, and to discriminate and analyse …will not at once be a lawyer […], or a physician, or a good landlord, or a man of business, or soldier, or engineer, or chemist […] but he will be placed in that state of intellect in which he can take up any one of the sciences,

or callings I have referred to, or any other for which he has a taste or special talent […]" [36]. That is the essence of an educated person.

But in today's understanding "transfer" will not take place if these subjects are taught independently of each other [37]. Since transfer will only occur to the extent we expect it to occur, the curriculum has to show how it can occur in what might be best described as interdisciplinary or trans-disciplinary situations. The failure to approach study in this way is the reason why a general education that comprises the study of a number of independently organized subjects is not liberal. But, "how can a basic liberal education link with the professional?"

The solution to be offered here is to be found in the origins of the Christian Brothers Technology Project.

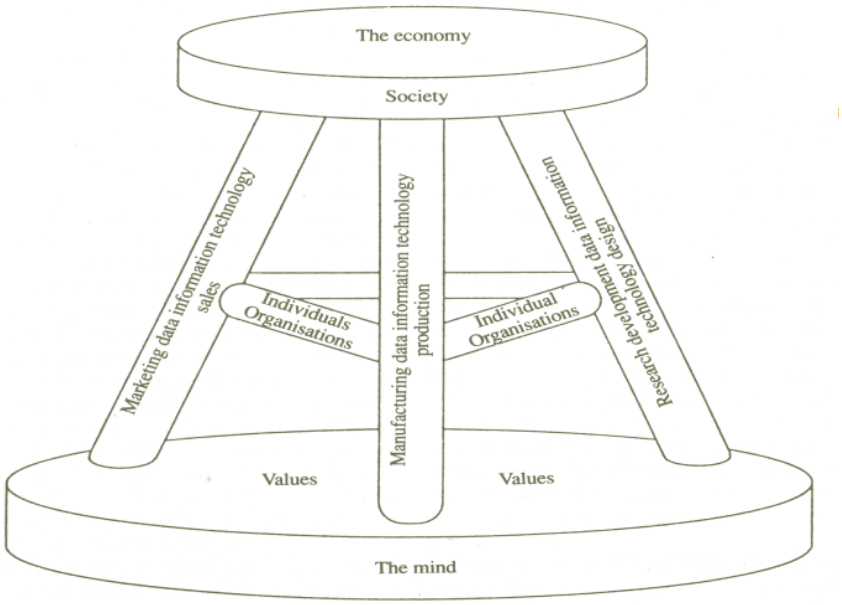

Exhibit 2

7. The activity (process) of engineering, and its product-technology

Exhibit 1 shows a model of the interrelationships between the areas of knowledge (engineering) and the achievement of a technological artefact for society and the economy [38]. When it was first sketched by Michael Murray, Glyn Price and myself in Glynn Price's room at Manchester University it was a three legged stool without support bars. Neither did it have a base. These legs represented the technological aspects of engineering; research, development, data acquisition, information technology, and design; manufacturing data and production; marketing data and sales. The first two legs are the domains of engineering science, design and manufacturing. The third leg is the knowledge domain of business, legal and economic understanding.

Using this model we tried to sell the Christian Brother's Provincials (leaders) a technology project with the aid of the thinking that led to the sketch. But they confronted us with the question, "Why should the Christian Brothers involve themselves in a project that is valueless?" or, words to that effect. That is how the base came to be added. It represents the person. The mind which supports the whole activity is the source of our values, beliefs and technical understanding: it is the source of the attitudes and opinions that we bring to the different social systems we have to occupy; it is the driver of our actions. Understanding how our beliefs and values (moral and otherwise) are formed is important for our conduct as engineers and individuals. It is at the core of any programme of liberal education. It

governs how we adapt to the plurality of social systems in which we live. It belongs primarily to the domains of philosophy and theology.

It highlights the need to understand how technology interacts with society and the person. Every individual needs to know how technology is able to control both society and individuals. The issue of "fake knowledge" means that we have to have an understanding of the concept of "truth" [39]. There is some understanding of pupil bullying on the internet, but the issues raised by the internet go well beyond that, and child pornography: substantial time should be devoted to them in the curriculum. They are far more important than learning coding.

Finally, persons, and therefore the personal are present in the activity of engineering as consumers of the technology it produces. Supporting the legs of the model are the trusses which represent individuals and the way the organization is structured. These are the domains of organizational behaviour and behaviour in organizations.

Engineering and technological literacy have as their objectives, the appreciation of engineering and technology through an understanding of the relationships as represented by the model. A major aim should be to address that major misunderstanding of western society which assumes that technology has a "*life of its own*". It is as Bucciarelli says "*romantic nonsense to think and talk this way out here in the big world. So too to imagine we can perfect a missile defense shield, that we can profit from the genetic manipulation of life at all levels without occasioning significant collateral damage, or that we can convince every scientist that global warming is upon us before it is too late to do anything about it- all of this is wishful thinking. It follows from a seriously flawed vision of technology, one that sets it apart and aloof, distant and seemingly out of reach of ordinary people. As citizens we ought to know and do better*" [40]. It also follows that a person who has not an acquaintance with engineering is not a liberally educated person. Nevertheless, from the perspective of liberal education the model is incomplete. For example, there is no requirement for history, the fine arts and music, literature or the learning of a language other than one's own. It is generally agreed that a liberal education would not be complete without attention to these. Fortunately, it is easy to insert them in the model [41].

8. Learning and teaching

Just as Newman's epistemology justifies the curriculum model presented so there is an epistemology that indicates the most appropriate approach to the teaching and learning that integrated or trans-disciplinary studies require. It comes from the work of the Scottish philosopher John Macmurray which I have considered in more detail elsewhere as it relates to practuical reasoning [42]. For our purpose today it is enough to say that Macmurray substituted "I do" for "I think" in Descarte's dictum "*cogito ergo sum*" As Macmurray put it in one of his lectures "*cogito non ergo sum*" [43]. All our activities begin with the practical. Finding out how to do what we want to do leads to our theories. So it is with learning, we learn that which we do. So the first stage of this curriculum should necessarily be problem or project based in which the problems or projects are arranged to ensure that the need for the other dimensions of knowledge and behaviour become apparent, and worthy of exploration. That stage is a stage of discovery but more so one of "romance", to cite the mathematician philosopher Alfred North Whitehead [44].

Whitehead's idea of romance comes from his view that "life is essentially periodic". Intellectual progress begins with novelty. "Knowledge is not dominated by systematic procedure". […] "Such a system as there must be is created piecemeal ad hoc" […] "Romantic emotion is essentially the excitement consequent on the transition from bare facts to the first realisations of the import of unexplored relationships". The next stage of progress he calls "precision". "It is the stage of grammar, the grammar of language and the grammar of science. It proceeds by forcing on the students' acceptance of a given way of analysing the facts, bit by bit. New facts are added, but they are the facts which fit into the analysis". This stage, he argues, is "barren" without the stage of romance. The final stage is "generalisation". "It is a return to romanticism with added advantage of classified ideas and relevant technique" [45]. It is a stage of synthesis that requires romance.

These stages may be used to characterize the differences between primary (elementary), post-primary (secondary) and university education. Some commentators have argued that universities have never got beyond the stage of precision, and that is why some university educators including engineers advocate learning from what goes on in primary (elementary) schools [46]. In terms of curriculum structure it can be seen that primary (elementary) education is a stage of interdisciplinarity, post-primary a stage for the subject disciplines and third level a return to interdisciplinarity.

But these cycles are going on all the time- short ones, long ones and even for a single event in the classroom. It would be a mistake to align them with the Piagetian stages because the evidence from young children in philosophy curriculum schemes suggests that children are capable of abstract thought. If that is so it would seem they are capable of precision and generalisation.

Much of Whitehead's theory of education is based on experience. It seems to me that everyday experience of tackling new fields is consistent with his theory. Learning is a process of discovery: to begin a new study we have to be in a stage of romantic emotion, that is, "the excitement consequent on the transition from the bare facts to the first realisations of the import of their unexplored relationships" [47].

The challenge of general education, and more particularly teaching, is to provide for romance in a range of subject areas for, if it can do that, and if the curriculum can be designed to show the relations ships between subjects, then skill in transfer should be developed. As Saupé said long ago; "transfer will only occur when there is a recognized similarity between the learning and the transfer situation" [48], and "transfer will only occur to the extent that students expect it to." To develop this skill so that it takes in knowledge at a cognate distance from the core is the challenge that Newman issues to general education.

Exhibit 3 shows how Whitehead's model was applied in the Christian Brothers Technology Project as a curriculum for the transition year. If interdisciplinary mini-projects are used in the stage of romance aspects of economics, human behaviour, the law and organization can be introduced and provide the basis for further study in the stage of precision.

The Christian Brothers trialled some parts of this model. It included intensive three week courses in manufacturing technology [49] and technical investigations [50] that were trialled with transition year students. These courses were developed because it is important that students experience practical work during the programme. Apart from the fact that the development of practical skills contribute to the development of the person, they may contribute to the development of creativity, spatial ability [51], and both practical and tacit knowledge [52]. They also assist with the acquisition of the transferable skills required by the technical workforce [53]. An independent evaluation of the project by Professor Heiko Steffens of Berlin Technical University was favourable [54]. Out of hours in service courses were also provided for teachers.

When Murray and Donovan made the original proposal for the Christian Brothers Project they wrote, "There is an argument *per se* for the introduction of courses in technological literacy. The need to heighten our awareness of technological development, to control and guide it was brought very clearly into focus by the Chernobyl disaster this year" [55, p 19].

It is a contention of this paper that this need has never been met, and that, in the light of technological innovation in the thirty years since, the imperative of being able "to control and guide it" is much, much greater, Just as then, it is in danger of being neglected, but this time in favour of technique.

The view presented is that the utilitarian approach to education that has dominated policy making has failed, and is not a suitable vehicle with which to address the dilemmas that technology is creating for society. That can only come from an education that is as conscious of the development of the individual, as an individual, considered as an end unto herself/himself. Individuals are the drivers of all behaviour. To meet their needs in a society that will often require of them "far" transfer, education needs to focus on the enlargement of their minds, while at the same time assisting them to acquire transferable vocational skills. Such an education will require new epistemologies of both the theoretical and the practical. Whether education systems can respond to such change is problematic.

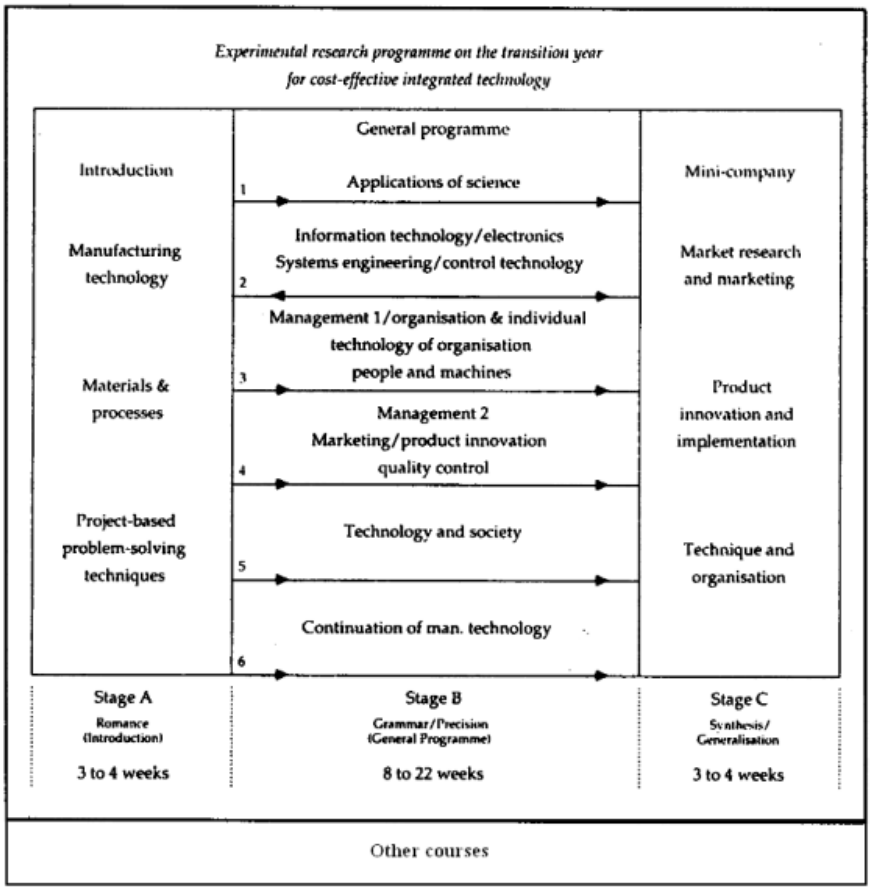

Exhibit 3

9. Changing the structure of education

It is extremely difficult to change educational structures. Everyone has a vested interest in education and very many, among them teachers, will resist change. So the key question is, "is technology so disruptive that change will be necessary? The view taken here is that that time has come. Given that educational systems owe their current situations to their cultural histories. There is unlikely to be a single response to such disruption, and many models will surely be developed.

Fundamental to these models is likely to be the idea of shortening the period of higher education to something that is "basic" and provides a base for further study at intervals throughout life. At least two models have been discussed. John Denham a former Minister for Higher Education in the UK proposed that the prevailing three year university courses in England should be reduced to two years by extending the existing 30 week year to 39 weeks. More recently the British Government has provided for experiments with two year programmes that jam 30 extra weeks into the two years. A two year undergraduate programme that is well-established and recognised in the U.K is run by the private University of Buckingham [56]

This writer has also discussed the idea of a basic two year programme followed by periodic returns to higher education. Alan Cheville has taken this thinking somewhat further. He suggests that students should take out an

insurance policy for a life-long engagement with their university so that they can either return to their university at intervals, or use e-learning to obtain immediately required knowledge, or knowledge for further personal and professional development. He envisages that there will be many pathways along which individuals can travel. The implications for credentialing are profound. First, credentials should no longer signify the end of education but should simply be indicators of personal and professional progress. Second, this implies that assessment is a record of progress that indicates a *labour arena* covered by the skills a person has demonstrated [57].

Whitehead's theory of rhythm in education provides a template for the development of the curriculum. It applies to any level of education and may act as a bridge between levels. In this model the basic stage of higher education be a stage of romance. Because of the instruction and learning facilities that are required it is best undertaken in a university setting. There is no reason why some if not all of the stage of grammar cannot be taken in an on-line learning environment.

Appendix

The Christian Brothers Technology Education Project 1985 – 1992

In 1984 the two Provinces of the Christian Brothers in Ireland appointed Brothers Michael Murray and Jim Donovan as Education Officers with the purpose of evaluating the curriculum needs of their schools in the light of changing economic and social needs. In the same year the Department of Education allowed some pupils in secondary schools to participate in Vocational Preparation Training Programmes as an alternative to the transition year. Brother Leo Canny, then Principal of Parnell Road School in South Dublin sought the assistance of the Professor John Heywood for the purpose of training his teachers in the design of courses for the VPTP.

In the meantime Brothers Murray and Donovan conducted seminars in more than fifty of schools (1,000 teachers) managed by the Christian Brothers [1]. Their study showed that teachers faced a number of difficulties but while recognizing "inadequacies in the present curriculum [were] reluctant to take part in new developments" because "they have not been trained, by and large, for school based curriculum design" [2, p18]. Murray and Donovan went on to write, "There is a lack of tutorial assistance and resource material which are absolute essentials to the implementation of any curriculum system".

The response of the Provincials was to found the Marino Curriculum Service for this purpose. It embraced the development that Brother Canny and Professor Heywood had begun and the first in-service course focusing on the needs of teachers undertaking VPTP courses was offered in the spring term of 1985 at St Mary's College of Education. This was the founding course of what came to be the Division of In-Service Education of the University of Dublin.

In the same report Murray and Donovan had also written, "There is a large imbalance in the system between the academic and the practical, the theoretical and the applied, the general and the vocational aspects of education. There is a high degree of compartmentalization viz. the scientific and the aesthetic, literacy and numeracy".

They were persuaded that there was a need to investigate developments in school technology and Brother Murray together with Professor Heywood (Head of Trinity College's Department of Teacher Education) a study of developments in the UK and Europe in which the Professor was actively involved. They concluded that "there is an argument *per se* for the introduction of course in technological literacy. The need to heighten our awareness of technological development, to control and guide it was brought very clearly into focus by the Chernobyl disaster this year" [3, p 19].

It is a contention that this need has never been met, and that in the light of technological innovation in the thirty years since the imperative of being able "to control and guide it" is much, much greater but just as then, in danger of being neglected, this time in favour of technique.

At the time the Provinces were persuaded to invest in the training of teachers to develop technology programmes for the Transition year, this being the one area of the curriculum where they could innovate without fear or favour. Supported by Dr Matthews of the Department of Teacher Education of Trinity College and the University of Salford's Technology Education bus, three courses were offered in the Summer of 1986 [4, p 29].

A conference was held in October 1986 that included contributions from some of those who had been consulted in the European study. During this conference it was announced that the Christian Brothers had commissioned the building of a multi-activity laboratory to serve as a centre for further development of staff development programmes in technological education. The plan of the laboratory was made available [5.p 30].

The final paper made the case for a curriculum for technological literacy based on a model that had been developed during the European study [6]. The principle purpose of this paper is to demonstrate the relevance of this model for today's curriculum.

Between 1986 and 1992 in-service courses, each of thirty hours duration were offered to teachers. Some courses were trialled with students. But the Provincials acting together with Professor Heywood were unable to persuade Ministers and their advisers in the department to support a

curriculum development project for the new Junior Certificate in schools. No rationale for this refusal was given. The lack of support made it inevitable that the work would discontinue..

One other point of note is that, given the success of an in-service programme which up-graded Home Economics Teachers who had qualified with Diplomas to degree level, a similar offer was made to the metal work teachers to up- grade them to degree level in school technology. This offer was declined

Notes and references for the appendix

[1] Murray, M and J. Donovan (1986). Resources and deficiencies in the voluntary sector of secondary education in Ireland in J. Heywood and P. Matthews (eds). *Technology, Society and the School Curriculum: Practice and Theory in Europe*. Manchester. Roundthorn Press.

Seminars were also conducted with such bodies as the Catholic headmasters Association, The Teaching Brothers Association, and The Conference of Convent Secondary Schools.

[2] *ibid.*

[3] *ibid*

[4] *ibid*. p 23/24. 68 teachers participated in the courses in electronics and/or microelectronics. Each of the units was of 30 hours duration. Agreement was reached with the University of Dublin for a 150 hour (5 units) Diploma in Curriculum Studies (Education for Transition). Negotiations were underway for a further Diploma in Management in Education.

[5] *ibid*

[6] Heywood, J (1986). Toward technological literacy in Ireland: an opportunity for an inclusive approach in J. Heywood and P. Matthews (eds). *Technology, Society and the School Curriculum: Practice and Theory in Europe*. Manchester. Roundthorn Press.

Notes and references for the main text

[1] *Edinburgh Review* (1809). A Review of Essays on Professional Education. 29, 40-53, October edition.

[2] Utilitarianism was promoted by Jeremy Bentham (1742 – 1832). The principle of utility approves of an action in so far as the action has an overall tendency to promote the greatest amount of happiness. (*Dictionary of Philosophy* (2005). Harmondsworth. Penguin, p 72).

[3] Teitelbaum, M. S (2014). *Falling behind. Boom, Bust and the Global Race for Scientific Talent.* Princeton. Princeton University Press.

[4] For example, Purves, L (2017). Let's Stop sneering at blue-collar careers. We need real parity of esteem in education and that means second-rate degrees are not better than tech qualifications. *The Times*, January 23rd.

[5] For example the U.K, Government's Enterprise in Higher Education Initiative 1989-1984 initiated by the Employment Department (= U.S. Department of Labor) was due to representations from industry.

[6] Margaret Hodge then Minister for Higher Education" claimed that graduates earned £400,000 more than non-graduates over a lifetime but their education is subsidised by 35% (twice as much as in the US). Her conclusion was that future students should foot the bill to finance the growing numbers of students and rectify a generation of underfunding" [Kemp-King, S (2016).*The Graduate Premium: Mana, Myth or Plain Mis-selling*. The Intergenerational Foundation (www.if.org.uk). London.]. This report argues that the graduate premium is probably less than £100, 000 but even if you accept this figure over 45 years, it only gives an annual premium of £2,222 per year, before Income Tax and National Insurance. That is simply not enough to cover the interest accruing on the average loan – bad news for young people and worse news for the Treasury as poorer students borrowing an average £53, 000 will accrue interest of £282, 420. 75, if their student loan is left unpaid for the full thirty years and then written off, as the current system promises. No wonder the government is keen to sell off the loan book).

In Ireland S. Corbet and C. Larkin have, as a result of a detailed study that included comprehensive comparisons with the UK and more significantly New Zealand, suggested on the basis of the evidence that an income contingent loan system would be a risky course of action for Ireland to take.

See Akers, B and M. M. Chingos (2016). *The Game of Loans. The Rhetoric and reality of Student Debt*. Princeton. Princeton University Press.

[7] McGrath, F (1962). *The Consecration of Learning. Lectures on Newman's Idea of a University.* Dublin. Gill.

[8] *ibid*

[9] *ibid*. McGrath cites J. Davison on the scope of literary studies "According to him they include ' religion (in its evidences and interpretations), ethics, history, eloquence, poetry, theories of general speculation, the fine arts and works of wit' Whether or not he was the author of the preceding review in the Quarterly, he gives the same description of the common nature of these seemingly diversified subjects, but is more specific. 'They are all', he says, 'quarried out of one and the same great subject of man's moral, social and feeling nature' (p35). McGrath comments that Davison does not enlarge further on the value of this study of man itself, but devotes himself at length to the consideration of the peculiar value it has in the training of the intellect.

[10] *ibid*

[11] Utilitarianism was promoted by Jeremy Bentham (1742 – 1832). The principle of utility approves of an action in so far as the action has an overall tendency to promote the greatest amount of happiness. (*Dictionary of Philosophy* (2005). Harmondsworth. Penguin, p 72).

[12] Brookings. Mortality and Morbidity in the 21st Century. Downloaded 10th May 2017. This paper is part of the Spring 2017 edition of *Brookings Papers on Economic Activity*.

[13] Newman, J. H (1947). *The Idea of a University Defined and Illustrated*. (edition edited by C. F. Harrold). London. Longmans Green (p156).

[14] *ibid*

[15] Sir William Hamilton (19852). *On a reform of the English Universities with special reference to Oxford and limited to the Faculty of Arts*. Cited by McGrath, pp 39 – 41.see ref 7.

[16] This bold statement was made in the SCANS report. SCANS (1992*). Learning a Living. A Blueprint for High Performance*. Washington. DC. US Department of Labor). The same point is made in respect of technical qualifications below that of a four year degree in (2017*). Building America's Skilled Technical Workforce. Committee on the Supply Chain for Middle-Skilled Jobs*. Washington, DC. National Academies Press, p 6.

[17] US Bureau of Labor Statistics; US Bureau of Economic Analysis. Cited in Erixon, F and B. Weigel (2016). *The Innovation Illusion. How so little is created by so many Working So Hard.* New Haven. Yale University Press. p 205.

[18] Christensen, C. M., Horn, M. B., Caldera, L and L. Soares (2011). *Disrupting College. How Disruptive Innovation can deliver Quality and Affordability to Post-Secondary Education*. Boston. Center for American Progress, Insight Institute, Harvard University. p 8.

[19] Goldrick-Rab, S*. Paying the Price: College Costs, Financial Aid, and the Betrayal of the American Dream.* Chicago. University of Chicago Press.

[20] Akers, B and M. M. Chingos (2016). *The Game of Loans. The Rhetoric and reality of Student Debt*. Princeton. Princeton University Press

[21] Kemp-King, S (2016).*The Graduate Premium: Mana, Myth or Plain Mis-selling*. The Intergenerational Foundation (www.if.org.uk). London

[22] Frey, C. B and M. Osborne (2013). *The Future of Employment*. Oxford. Oxford Martin Programme on technology and Employment, Oxford University.

[23] Aldrick, P (2017). Robots may be taking our jobs, but that is no reason to tax them. *The Times*. February 21st.

Avent, R (2016). Welcome to the world without work. Special report. *The Observer* 9th October. .pp 37-39.

[24] *loc.cit* ref 22

[25] Susskind, R and D. Susskind (2015). *The Future of the Professions. How Technology will transform the work of Human Experts*. Oxford. Oxford University Press.

[26] Carey, K (2015). Here's what will truly change higher education: online degrees that are seen as official. *New York Times*. http://www:nytimes.com/2015/03/08/upshot/true-reform-in-higher-education-when-online-degrees-are-seen-asofficial.html?abt=00028abg=0

[27] *Information Technology and the U.S. Workforce. Where are and Where Do We Go from Here*? (2015. A report of the National Academies of Sciences, Engineering medicine. Washington, DC. National Academies Press.

"Because most jobs involve multiple subtasks, and because technology typically targets specific tasks, one common impact of technology is to shift the distribution of tasks the human worker performs in a job (e.g., authors today spend less time proof reading for incorrect spelling enabling them to spend more time on the content of what they are writing). Technology also makes new tasks and new jobs possible transforming the nature of work in many, and ultimately most, industries" (p138).

[28] *ibid*

[29] For example, Ridley, M (2016). Let's stop being so paranoid about androids. Pessimists have always warned that automation will abolish everyone's job, yet it continues to improve our lives. *The Times*, November 21st.

[30] *loc.cit* ref 25.

[31] *ibid*

[32] *loc.cit* ref 27.

[33] SCANS Report (1992). *Learning a Living: A Blueprint for High Performance*. Washington, DC. US Department of Labor.

[34] Enterprise in Higher Education Initiative. Details in Heywood, J (2005). *Engineering Education. Research and Development in Curriculum and Instruction*. Hoboken, NJ. IEEE Press/Wiley.

[35] Costello, J. E (2002). *John Macmurray. A Biography*. Edinburgh. Floris books. p 316 ff.

[36] Newman, J. H (1852). *The Idea of a University* (with additional lectures added in 1873. 1923 Impression). London, Longmans, Green. Discourse VI. p 166. Newman did not conceive of enlargement being caused by a wide range of knowledge though the study of a large number of subjects. […]"Liberal education is not mere knowledge, or knowledge considered in its *matter* […] whether knowledge, that is, acquirement, is after all the real principle of the enlargement, or whether that principle is not something beyond it". P 130. For a commentary see Culler, A. D. (1955). The *Imperial Intellect. A Study of Newman's Educational Ideal*. Yale University Press. Pp 204 – 208. The principles of Newman's theory of knowledge will be found in his University Sermons especially No 14.

[37] Transfer is related to critical/reflective thinking. See Heywood, J (2000) *Assessment in Higher Education. Student Learning, Teaching, Programmes and Institutions.* London, Jessica Kingsley. Section on the critical thinking movement in higher education pp 177 – 181 and 187 to 191.

[38] Heywood, J (1986). Toward technological literacy in Ireland: an opportunity for an inclusive approach. In J. Heywood and P. Matthews (eds). *Technology, Society and the School Curriculum*: *Practice and Theory in Europe.* Manchester, Roundthorn. P 234.

[39] d'Ancona, M (2017). *Post Truth. The New war on Truth and How to Fight Back*. London. Ebury Press.

[40] Bucciarelli, L. L (2003). *Engineering Philosophy*. Delft. Delft University Press. p101.

[41] Yakman, G. M (2008). http://www.steamedu.com/2008_PATT-Publication.pdf Cited by Zeidler, D. L (2014). STEM education: a deficit framework for the twenty first century? A sociocultural socioscientific response. *Cultural Studies of Science Education* DOI 10.1007/s11422-014-9578-z.. 26th June.

See also the SCANS report (ref 16) which shows how key competencies required for work can be integrated into the subjects of the school curriculum. Is summarised in details in Heywood, J (2008*). Instructional and Curriculum Leadership. Towards Inquiry Oriented Schools.* Dublin. Original Writing for National Association of Principals and Deputies.

[42] Heywood, J (2102). Philosophy and undergraduate teaching and learning. Perspectives for engineering education. *Proceedings Annual conference of the American Society for Engineering Education*. Ethics Division.:

"It is only when we turn to consider our practical experience as agents, and not our theoretical experience as thinkers, that we discover the true character of reason. This is the final and quite revolutionary conclusion of the Critical philosophy. Reason is primarily practical. It is not a faculty of cognition, but a faculty of rules. If it has a secondary, theoretical function that is because thinking is something that we do; so that Reason is necessary to provide the rules that guide our search for knowledge. The understanding, which is theoretical, is, as it were the viceroy of reason in the theoretical field. Reason itself is the ultimate legislator. This is the dignity of reason. For Kant –and as a philosopher- action is more important than knowledge. If it was important to distinguish science from art, it is much more important to distinguish morality from art. The major danger which Kant saw in the uncritical idealism of the romantics was this confusion- the danger of substituting aesthetic for moral standards in the determination of conduct. Indeed science itself, as a human activity, depends on practical rationality" [a]. Embedded in this comment and more so in Macmurray's general discussion is clearly a portrayal of 'engineering reasoning'. The differences between science and engineering arise from the practical ends they have to serve. Most recently these practicalities have been defined in terms of the problems that on the one hand, scientists' (physicists), and on the other hand engineers have to solve. 'Engineering reasoning' leads to a different kind of knowledge to that of science. It is about the results of engineering design.

Macmurray argued that "there is a necessary interplay, in all human activities, between theory and practice. It is characteristic of Man that he solves his practical problems by taking thought; and all his theoretical activities have their origins, at least, in his practical requirements. That they also find their meaning and significance in the practical field will command less general assent; yet it is, in my belief, the truth of the matter, and one of the major theses to be maintained here. Activities of ours which are purely theoretical, if this means that they have no reference to our practical life, must be purely imaginary-exercises of phantasy which are not even illusory unless we relate them to the practical world by a misplaced belief. The truth or falsity of the theoretical is to be found solely in its reference to the practical"[b].

Macmurray substitutes 'I do' for 'I think'. One of his public lectures on the primacy of action over thought was titled '*Cogito Ergo Non Sum*" [c]. The Self as subject then is not part of the world it knows'! [d]. If this is taken to be the position of engineers and engineering in the real world, then epistemological studies in the absence of an understanding of what it is that engineers do as an activity are irrelevant to the central problems of engineering education.

[a] Macmurray, J (1957). *The Self as Agent*. London, Faber and Faber.p 54.

[b] *ibid* p 21.

[c] Costello, J. E (2002). *John Macmurray. A Biography* Edinburgh, Floris books. p 323.

[d] *ibid* p 325. Costello summarise the full structure of personal logic as follows, 1.The Self is agent and exists only as agent. 2 The self is subject but cannot exist as subject. It can be subject only because it is agent. 3. The Self is subject in and for the Self as agent. 4. The Self can be agent only by being also subject.

[43] Costello, J. E (2002). *John Macmurray. A Biography* Edinburgh, Floris books

[44] Whitehead, A. N. (1932 -1959 9 impression) *The Aims of Education and other Essays*. London, Benn. The idea of connectedness in education will also be found in the first essay on the aims of education. he though subjects taught in school were fatally disconnected. See pp 10 to 12. But that did not mean that a vast number of subjects should be taught. Rather "Do not teach to many subjects, and again, what you teach, teach thoroughly" p2.

[45] *ibid*

[46] Crynes, B. L and D. A. Crynes (1997). They already do it: common practices in primary education that engineering educators should use. *ASEE/IEEE Proceedings Frontiers in Education Conference*, 3, 12-19.

Heywood, J (2002). "SCOOPE" and other primary (elementary) school project with a challenge for engineering education. *ASEE/IEEE Proceedings Frontiers in Education Conference*, 2, E2C- 6 to 10.

[47] *loc.cit* Ref. 43

[48] Saupé, J (1961). Learning in P. Dressel (ed) *Evaluation in Higher Education*. Boston. Houghton Mifflin.

[49] Owen, S and J. Heywood (1990) Transition technology in Ireland. *International Journal of Technology and Design Education*, 1 (1), 21 – 32.

[50] Kelly, D. T and J. Heywood (1996) Alternative approaches to K – 12 school technology illustrated by an experimental course in technical investigations. *Proceedings Frontiers in Education Conference*, 388 – 391(AEE/IEEE).

[51]. By "practical" is meant making things (as in ref 48) as opposed to putting things together (e.g electronic circuits).

For the significance of spatial ability in technology education see MacFarlane Smith, I (1964). *Spatial Ability*. London. University of London Press, and Chapter 5.4 of Heywood, J (2005). *Engineering Education. Research and Development in Curriculum and Instruction*. Hoboken, NJ. IEEE/Press. Wiley InterScience.

[52] Practical intelligence and tacit knowledge.

Sternberg and his colleagues included within the domain of practical intelligence, practical problem solving, pragmatic intelligence and everyday intelligence

"Practical intelligence involves a number of skills as applied to the shaping of and selection of environments" (which Sternberg argued is what intelligent people do). "These skills include among others (1) recognizing problems, (2) defining problems, (3) allocating resources to solving problems, (4) mentally representing problems, (5) formulating strategies for solving problems, and (7) evaluating solutions to problems" [a].

Hedlund and Sternberg considered that what differentiates emotional from social and practical knowledge is "tacit knowledge." That is, the knowledge that is not taught, but acquired as part of everyday living. As Michael Polyani who identified this category of knowledge put it "We know more than we can tell" [b]. The idea is vividly captured in Yorkshire dialect by the term "nouse!" [c] This knowledge is acquired from managing one's self, managing tasks, and managing others. It is as Trevelyan has shown of major importance in the practice of engineering [d].

A key skill in the development of tacit knowledge is self-reflection yet the Sheffield study found that engineering students do not like to self-reflect. "They were not used to talking in terms of feelings, nor could they see the relevance of such reflection to learning about engineering problems." Whether or not one should talk about one's feelings has become a matter of debate in the UK since Prince Harry revealed his difficulties that arose from the death of his mother this year [e]

"The ability to acquire knowledge, whether it pertains to managing one's self, managing others, or managing tasks can be characterized appropriately as an aspect of intelligence. It requires aspects such as encoding essential information from the environment and recognizing associations between new information and existing knowledge. The decision to call this aspect of intelligence social, emotional, or practical intelligence will depend on one's perspective and one's purpose" [f].

[a] Sternberg, R. J and E. L. Grigorenko (2000). Practical intelligence and its development in Bar-On, R and J. D. E. Parker (eds). *The Handbook of Emotional Intelligence.* San Fransisco. Jossey Bass.

[b] Polyani, M (1966). *The Tacit Dimension*. Garden City. Doubleday.

[c] Nouse alternative Nous. Intuitive apprehension: common sense, practical intelligence, gumption (The New Shorter Oxford English Dictionary. Oxford University Press.

[d] *loc.cit* ref 9. James Trevelyan writes that engineers should have "the ability to value, acquire, develop, and use tacit ingenuity which is compiled in a vast library in your mind composed of 'how to' fragments of unwritten technical and other knowledge. Your progress as a student depended on knowledge that you could write down in examinations, tests, quizzes, etc. In engineering, your progress depends much more on knowledge that is mostly unwritten, the kind that is carried out in your mind and the minds of other people. To acquire this knowledge, you may need to strengthen your ability to listen, read and see accurately." […] "You need to understand what engineering is, how it works and why it is valuable. Value is a multidimensional concept: economic value, namely making money for yourself and others, is just one dimension. Other include caring for other people, social justice, sustainability, safety social change, protecting the environment, security and defence […] "you won't be able to find your way without knowing the point from which you are taking off. You will need the ability to understand yourself and where you are today" [pp 43-44].

[e] Giles Coren's column *The Times* Saturday 22nd April 22nd 2017.

[f] *loc.cit* ref. a.

[53] *loc.cit* ref 16.

[54] Steffens, H (1991). Motivating technology education- evaluation of the in-service course "manufacturing technology" in Dublin in M. Kussmann and H. Steffen. *Current Topics of technology Education in Europe*. EGTB report No 1 pp 47-51.Europäische Gesellschaft für technische Bildung. A more detailed version will be found in Steffens, H (1991). Retraining teachers for the new technology education programmes in Ireland. *International Journal of Technology and Design Education,* 2(2), 3 -35.

[55] Murray, M and J. Donovan (1986). Resources and deficiencies in the voluntary sector of secondary education in Ireland in J. Heywood and P. Matthews (eds). *Technology, Society and the School Curriculum: Practice and Theory in Europe*. Manchester. Roundthorn Press.

[56] See *The Times*, 24th February 2017 and letter responses 27th February 2017.

[57] Youngman, M. B., Oxtoby, R., Monk, J. D and J. Heywood (1978). *Analysing Jobs*. Aldershot. Gower Press.

"Our concept of a' labour arena,' that is, of a group of skills which is already possessed or which may be readily acquired, crosses the divide of job perceptions derived from job titles" p 106.

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John Heywood's research interests are in engineering education, its philosophy, curriculum and instruction. He came to Trinity College Dublin, where he was Professor of Teacher Education between 1977 and 1996, from the Faculty of Engineering of Liverpool University where he lectured in industrial studies and management. Prior to that he conducted research at Lancaster University into examinations and assessment, and

designed new models of assessment for engineering science in schools. While at Trinity he developed a national programme of continuing professional development for teachers, and directed the Marino Curriculum Service.

In the 1970's he directed the first major study of engineers at work for the purpose of determining objectives for training technologists and technicians. His 2005 award winning book on "Engineering Education. Research and Development in Curriculum and Instruction". He has over 100 publications. These include "Instructional and Curriculum Leadership" and "Managing and Leading Schools as Learning organizations" both sponsored and published by the National Association of Principals and Deputies. His most recent book on "The Human Side of Engineering" was published earlier this year.

Dr. Heywood served in the Merchant Navy and Industry before teaching radio subjects at Norwood Technical College where he co-ordinated the amateur radio observations of Sputniks I and II and edited the first handbook for radio and visual observers of artificial earth satellites. He holds a higher doctorate from Trinity College. He is a Life Fellow of the American Society for Engineering Education, and the Institute of Electrical and Electronic Engineers, and an Honorary Fellow of the Institution of Engineers Ireland. In 2016 he was awarded the Pro Ecclesia et Pontifice Medal by Pope Francis for his services to education.