Formative Influences on Technology Education: The Search for An Effective Compromise in Curriculum Innovation

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Successful curriculum development in our schools and colleges relies on compromise and interplay from a number of interested parties, some of whom are competing for recognition and resources. The interests which these factions represent vary and are not immediately apparent. While to some, the basis of curricular innovation lies soundly in the philosophical ideals of the educator whose sole concern is the successful development of the full potential of the child, to others the curriculum is perceived as having more instrumental aims which include the interests of the state and society at large.

In addition to philosophical foundations, most innovators have to bear in mind the political and economic interests of stakeholders in technology education (e.g., school governors, national governments, industrialists and parents) as well as the classroom practicalities that result from the teaching/ learning strategies available. Unfortunately, while these constraints are understood by curriculum planners, they are frequently ignored and the evolution of the curriculum is still a haphazard affair which does not necessarily occur in a logically, ordered, and planned fashion.

The Technology Education Curriculum in the United Kingdom is a prime example of how the evolution of a subject has been distorted both by a philosophy which was allowed to assume credibility without an empirical verification of its practicality and also political imperatives which led to changes being implemented without sufficient preparation (Eggleston, 1991). Fortunately, and in some ways undeservedly, the results of such hegemony have been to some degree ameliorated by the professional practice of teachers. The strategies utilized by these practitioners are frequently implemented unconsciously and rely on craft skills which have been handed down through generations of teachers as well as being developed as part of their stock in trade through experience of "what is possible" within the constraints of life at the "chalk face." The current curriculum (DFE, 1995) is a praiseworthy attempt to rectify errors which would never have occurred if the basic tenets of a "process" model had been used by the curriculum developers during the planning stage of the innovation.

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The imperatives of political philosophy and expediency frequently influence the formation of educational policy. The philosophy of the political right wing for example may expect the concept of entrepreneurship to pervade the technology curriculum and a Marxist philosophy may seek to encourage learning through practical endeavor as fundamental for the development of an educated citizen (McCormick, 1993). The acts of politicians may also however, be a reflection of the concerns of their constituents (e.g., industrialists and parents), their concern over the needs of their country (e.g., the needs of the economy) or the even less altruistic considerations of the ballot box (technology is currently seen to be a "good thing"). It must be recognized that these concerns are legitimate in that politicians are said to be representative of their electorate and that not to represent these views could be deemed a dereliction of their duty. The primacy of the dominant position however may not be coincidental with the best interests of the child or even that of "technology" itself.

Beyond these political concerns at the macro level, there are also the political considerations evident within the institutions and professional organizations which are the providers of technology education at first hand (Ball, 1987). Within England and Wales, the technology curriculum has been inherited, in the main, by teachers who have previously been instrumental in delivering, Craft, Design and Technology, Art, Home Economics, and Business Education; all traditional subjects which bring with them an established background of knowledge, custom and practice. While these subjects may have similarities, they also have considerable differences in philosophy and working practices. If it is further understood that the subject of Craft, Design and Technology has itself emerged, within recent memory, from the traditional handicraft areas of woodwork and metalwork, it can be seen that the potential for conflict within the politics of an institution is great and will be ignored only by the foolhardy.

For whatever the reason or combination of reasons the government of the United Kingdom has, over the last decade or so, produced a range of innovations (Layton, 1995) which have been directly concerned with technology education and which, within established philosophy and historical precedent have proved to be controversial. With the implementation in 1990 of the National Curriculum (Department for Education, 1995) the government took from the hands of the teaching profession responsibility for the content of the school curriculum. This act resulted in the introduction of technology as a compulsory component of the education of all children within the state system.

This development has been surrounded by other curriculum initiatives such as the Technical and Vocational Education Initiative, in which the government of the UK attempted to influence the curriculum of mainly 14 to 16 year old children. They accomplished this in several ways. First, through the provision of enhanced resources attained through success in competition between schools and Local Education Authorities. Second, by the establishment of City Technology Colleges, which are independent schools funded mainly by central government but also through commercial and industrial interests. And finally through independent educational initiatives such as "Learning Pays" by The Royal Society of Arts (Ball, 1991) and The National Commission on Education (NCE, 1993). All of these innovations have been made, at least in part, to enhance the competitive position of British industry in the world economy.

This desire to increase the competitiveness of the nation has influenced not only the curriculum, in that technology is now a compulsory and major component, but also the form the subject should take. The requirement that schools—and to a much greater extent universities—should provide innovative people to fuel the wealth generation of organizations and indeed states have had influence upon both the content and teaching methodologies employed. This necessity is said to require the production of a workforce which is adaptable and which has competence in a number of generalized problem solving skills which may be transferable to meet new and ever more problematic situations. This has been interpreted as reflecting the "process view" of technology. Technology, however, is a very complex subject and the process definition reflects only a partial understanding (Custer, 1995).

In defining technology, and then technology within the school curriculum, it must be borne in mind that perceptions are colored by a number of factors such as culture, occupation, geographic location and education. While to some, technology is an object or artifact, to many it is an activity which is defined substantially by human intervention. The complexity of this intervention and consequently its "concept web" is dictated by the activity undertaken. The development of a space vehicle will call upon the employment of a different and probably wider range of skills and knowledge than say the plowing of a field with an ox. Both will require skill, understanding, and organization but these will be different even though they may be equally important to the participants. Both will also impact upon the environment and consequently society.

Technology is therefore about knowledge, both scientific and also that perhaps best described as experiential, about understanding and also about *doing.* Technology, however, perhaps is most easily categorized as being concerned with implementing ideas. This understanding suggests that while it is possible to recognize how something functions and therefore have a technological comprehension, it is necessary to implement a solution to a problem before a claim can be made for technological capability. The capability, therefore, requires further attributes which may be described as problem solving skills to give life to this comprehension. Knowledge does not, however, stay still. It is constantly changing (some may become redundant) and expanding, as are the demands made upon technologists to meet new challenges.

This perception that technology is a dynamic subject with a body of knowledge that is constantly changing is important to our concept. As the value of redundant knowledge is limited, the content of any course in technology education should not solely be a collection of facts which are likely to be superseded but must include problem solving strategies aimed at bringing about change.

In addition to this instrumental view of technology and its value for the economic well being of society, there is the further supporting philosophy which suggests that the major aim of education should be to enable children to "make sense" of the world around them. The only way they can do this is through implementing strategies which allow them to discriminate between what is of value and that which is spurious. Here the all pervading role of technology in the modern world provides a self-fulfilling imperative in that all citizens of a modern state should know about and understand the role of technology to allow them to function effectively in societies which are technologically driven. If this knowledge is refined so that it becomes process driven, that is technology is about strategies and approaches which will allow the individual to cope with change, so much the better (Toffler, 1970).

Another commonly used argument in support of this designing and making approach, lies in the theory that children learn best through *doing*. Therefore through involving children in practical project work they enhance their technological understanding by applying theoretical principles to “real life” situations. This philosophical ideal has considerable theoretical justification and active learning approaches are an accepted part of the educational scene in England and Wales.

This range of justifications is represented in Figure 1, which shows that these perceptions are in effect extremes of continuums, the opposing ends of which have advocates who are often vociferous in giving voice to equally extreme views.

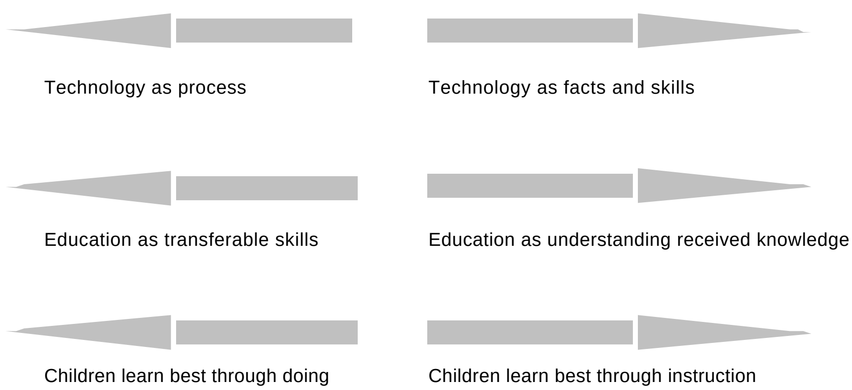

Figure 1. Technology education through a process approach.

These extremist viewpoints can be perceived by the uninformed as having a degree of credibility which is unjustified particularly when examined within the context of the day-to-day life of the average teacher. As in most scenarios, the reality of the situation is one of compromise. This compromise, however, must be made in the light of information gained through a careful examination of as wide a debate as possible rather than the view that is expressed from the loudest bandwagon.

The Practice

While all of the arguments noted above are difficult to refute, both in their appeal to logical thought and also as a reflection of what many would say is good practice, I think it is fair to say that the implementation of national curriculum for technology in our schools has not been as successful as many would wish (Smithers and Robinson, 1992; Department of Education and Science, 1992). But it is also proper to record that some of the deficiencies have been recognized and improvements have been made in recent years (Office for Standards in Education, 1995).

As could be expected, the reasons for this lack of success are many and they vary with their source. From some commentators, the reasons lie in the lack of understanding and expertise or commitment within the teaching force, while from teachers it is frequently the lack of resources which is the main problem. While no doubt there may be more than a smattering of truth in both of these viewpoints, there are more basic and fundamental reasons for the lack of success in implementing a subject which was seen to be exciting and innovative at its conception but more challenging in its implementation.

There was an initial underestimation of the complexity of what was being required of teachers who either by their initial education or philosophical inheritance, found the process model difficult to internalize. This, coupled with what can only be described kindly as complicated and impracticable advice from the innovators, led not only to alienation, but also in some cases to a feeling of guilt from teachers who felt they were failing in the task of implementing “good practice.”

This may be illustrated in the confusion which lies between the teaching and learning methodologies they adopt and their attempts at enhancing the children's understanding of technological process. A prime case could be of evaluation when often children (and their teachers) confuse the task of evaluating a technological outcome, (artifact, process, system etc.) with their performance as a designer. While an element of self-appraisal on the part of the child is valuable to guide their own learning, there often appears to be no delineation between the two aspects of their work or clarification of the sub process as a part of technology. This stems from a fundamental shortfall in the teacher's understanding of the philosophy of their subject and consequently a confusion in setting objectives which are achievable.

The most fundamental error which has been made is the translation of a model or algorithm for technology (or design) into a teaching and learning strategy (Norman and Roberts, 1992) for a curriculum subject. While such models may (or may not) describe what technology is, it does not follow that for children to learn and understand such an interpretation requires them to slavishly follow such an approach in the activities which they carry out. In other words it is essential to learn what is meant by, and how to carry out tasks such as technological analysis, as well as doing the analysis as part of a process. If such skills as analysis, synthesis and evaluation are to be developed as the prime function of the learning experience, we must understand how to promote these within the classroom, and this task may be carried out with a technological focus. It seems to me axiomatic that to evaluate a technological product, children must be aware of both techniques and skills to carry out this evaluation as well as having an understanding of technology to use as a yardstick. Neither aspect on its own is sufficient.

Unfortunately it appears that research is at a comparatively early stage in determining both what a process view of technology means to a teacher (as opposed to say a designer or professional technologist) and consequently how this meaning may be translated into professional practice.

Problems also become evident in evaluating the learning activities and planning programs. The evaluation of process learning is difficult (Kimbell et al., 1991). In the pragmatic eyes of the teacher the product of the exercise becomes the file or notebook or portfolio of evidence which may complement the outcome of the technological assignment or task. The objective of the teacher very quickly becomes the production of well presented evidence as opposed to the enhancement of the understanding of the process by their charges.

A further misconception lies in the problems which occur in the management of problem solving within the technology classroom and the school. Perhaps the most exciting and certainly the most demanding feature of a content-free approach lies in the extremes to which its most enthusiastic supporters go to meet their ideals. The ideal becomes the situation whereby children can operate as autonomous individuals in the selection of the task and then bringing it to its successful fruition through the utilization of appropriate resources and the application of acquired skills. This strategy is meant not only to develop problem solving skills but also to equip the child with the psychomotor skills and technical knowledge necessary for further development.

This ideal situation, however, can easily result in difficulties in managing the classroom. If freedom is offered to a group of children to identify a problem (or discover an opportunity for improvement) which can be overcome by designing and making an artifact, within say the context of the school or the home without establishing parameters for either the area of expertise to be employed or resources available (materials to be worked, components used, equipment available) it would appear obvious that the demands made on the teacher would be excessive and consequently that the opportunities for learning could be limited.

In other words a restraining factor must be applied so that the experience can be structured and the child can obtain the greatest benefit from the time available. Even if this management is restricted, a balance has to be reached between freedom of choice and meaningless tasks which are contrived to produce established or pre-ordained solutions.

The complexities of this task at the classroom level are mirrored to some extent by the organization of technology within schools. To facilitate manageable units teachers are grouped, with varying degrees of success, to provide the most viable range of expertise and physical resource needed to facilitate the disparate range of problem based learning experiences which can evolve. These groupings in practice can be quite arbitrary and frequently reflect the managerial problems of the school rather than focus upon a coherent philosophy of technology education. The dissonance which is almost certainly produced by organizational change (Ball, 1987) is often counter-productive in establishing the coherent philosophy demanded by a subject which is dependent upon a range of disparate disciplines.

In addition to the philosophical and management dimensions of curriculum change pedagogical theories must also be considered. While there are times when behaviorist or instrumental theories of learning can be seen to have relevance, particularly in the acquisition of low level facts or knowledge, the complexity of what is required of the learner within current philosophies of technology education apparently demands more than the simple transfer of knowledge by didactic exchange or rote learning. It is due to this recognition that the importance of cognitively contextualizing the concepts to be acquired, becomes significant. This categorizing of new learning within established constructs is not only carried out by the learner as he or she makes sense of the new concept, that is how can it be “catalogued” in terms of previous knowledge or understanding, but is also part of the portfolio of the effective teacher. The need is there for the teacher to identify for the student, or at least refine their understanding, of the most appropriate perceptual cues they are receiving, so that they can develop an increasingly meaningful understanding of the concept with which they are involved.

In other words there is the need for a structured approach to teaching the process so that learning can be effective. Teachers should direct students so that they can draw appropriate conclusions and motivation from the tasks rather than to simply give them the solutions. This higher order learning is the product of negotiation, an initiation into a socially constructed network of beliefs and opinions. It is much more than the transmission of knowledge.

Conceptual understanding is formed through a person's experiences of reality (Stones, 1966) and as this reality is constructed partially through social interaction the increased opportunity for tailor-made learning is valuable. Summers and Kruger (1992) describe how the concept of energy can vary between a chemist, physicist and a biologist, not because these concepts are incorrect but because the emphasis placed on different aspects will vary with the context.

The value of socio-cultural theories of psychological development, particularly scaffolding, are of interest to technology educators, especially the importance of social interaction and the social context (Gredler, 1992; Kincheloe and Steinberg, 1993). The principle of proximal development (Tharp and Gallimore, 1988) has similarities in apprenticeship training, well known in the traditional fields of technology and craft training. In the practice of process methodology in which the teacher works closely with the child in the development of his or her ideas there are echoes of this apprenticeship model. With the timing, quality and quantity of the teacher interaction varying according to the needs of the pupils the “scaffolding” of the learning experience varies to suit the needs of the children at that stage of their development (Tharp and Gallimore, 1988).

Teaching however is also about spontaneous actions based not only on knowledge but also on miscellaneous experiences from a variety of practical sources. The teacher's skill lies not merely in the application of theories but in adapting these understandings to the environment (in its broadest sense) in which they are practicing (Hamilton, 1982; Stenhouse, 1980).

It is a lack of this understanding in implementing curriculum reform which creates doubts about the effectiveness of process methodology not only within the profession but also within society at large. The process driven approach within technology education is one example of where the implementation of fundamentalist ideals without the pragmatic considerations of the practitioner has caused anxiety.

If taken to extremes, the advantages to be gained for children working by themselves engaged in problem solving are not only negated but may result in alienation, if the teacher cannot devote the time necessary to engage the learner in critical discourse. In a group of say twenty children working with one teacher, there is barely two minutes per child (after administrative and organizational tasks are removed) in each hour for personal and meaningful interactions to take place, and in practice most of these interactions are of a low order. From my own observations, an interaction rate—that is different contacts between teacher and child of over 60 per hour is not unusual.

To compensate for this lack of quality time, it appears that what happens is that the teacher often “feeds” the children with established solutions to their problems thus in practice teaching in a traditional didactic fashion. This is not only apparently a contradiction in methodological terms but also an unnecessary waste of the time of the teacher, in repeating the same instructions and advice a number of times, to each individual but also for the children who are waiting for advice.

The subconscious application of a collection of principles and practices which have been successful in the past in meeting novel situations may be part of the technology teacher's stock-in-trade. The use of such strategies would normally mitigate against the introduction of new teaching approaches, particularly when the approaches are ill defined and not sufficiently articulated (Eraut, 1994), conversely they may be the means of salvaging some degree of success.

The teachers may in fact be employing strategies to develop the skill base and subject knowledge of their students through a traditional understanding and in employing this tactic they are applying the findings of Glaser (1993) whose work suggested that in both experts and novices alike, problem solving difficulties can be attributed to inadequacies in their knowledge base.

Technology teachers, particularly those in the UK, have backgrounds in subjects which have been historically based in crafts which have been defined over centuries. Often their view of their subject and frequently their own education has been strongly influenced in ways which are different to that of their “academic” colleagues. This difference is often exhibited through pride in their practicality, that is through not being “merely talkers,” and through a self confidence in their own skill in their craft. Their professional knowledge and skill as teachers has therefore a different root, it has emerged from the experience of having to produce a good product in order to make a living. And while a logical and methodical approach to their work is essential for success, so is knowledge and skill. Such considerations are so ingrained in this professional understanding that to disregard them is not only casting considerable doubt on the integrity of many conscientious practitioners (Rudduck, 1988), but also not even examining the evidence of a methodology which has served us well in the past. This is not however a cry from the heart of a backwoodsman who wants a return to the "good old days," but a statement of the obvious, which one suspects, is often deliberately overlooked.

We need, therefore, to ensure that a core of knowledge is not only made explicit but also taught in a structured manner. This approach coupled with the views expressed earlier that process should also be taught incrementally, is essential if "school technology" is to be given the credibility it deserves.

Further developments which indicate that change in this way is necessary, includes the work by Barlex et al. (1994), which advocates the need for both resource tasks and capability tasks in a program of technology. This approach is similar to the focused tasks and activities of the new National Curriculum (DFE, 1995), an approach which appears to draw heavily on the work of Black and Harrison (1990). These developments are recognizing, in implication if not in direct statement, the need for structured inputs of skills and knowledge and not merely the acquisition of random information on a need-to-know basis.

Conclusion

In conclusion it would appear that there are significant dangers in attempting to implement complex curriculum change through central direction without a considerable degree of planning and preparation. While this may appear to be self-evident, it is unfortunate that a top down strategy of implementation is more often the norm—certainly within the UK—than a more rational and dare it be said problem solving approach which includes the training and participation of the practitioners.

I am sure that the principle of a problem solving foundation to technology education is correct. Such a view is however only the first base in realizing its potential. A deeper understanding is required, not necessarily about the content base of technology, (we are not best equipped to be at the forefront in this field, although a sound subject base is essential) but about the professional issues which are our primary concern. It is one thing to teach a group of children about the principles of structures, but quite another to teach about generic strategies required to analyze the aesthetics of a structure or the socio-economic effects it may have on the neighborhood. Technology teachers are well versed in transmitting "making" skills and technical knowledge, but they must also contribute to the development of strategies which lead to the elevation above the more mundane elements of the process strategy—the deeper understandings said increasingly to be at the core of our subject.

The most basic requirement would appear to be some verification that the proposed changes can deliver what is claimed for them not only through a theoretical overview, which bases its projections upon a wish list, essential as this is, but also grounded upon a planned program of empirical research. Furthermore this research must reflect the scene in our average schools and not merely reinforce the practice of enthusiastic experts working in atypical environments. While technology education has, to a certain degree, benefited from claiming to be all things to all people through the influences mentioned earlier, it must learn to divest some of the claims made for it so that expertise and energy may be directed more meaningfully to an achievable goal. Claims are being made that technology education within our schools is instrumental in enhancing problem solving skills, craft skills and knowledge, aesthetic awareness, graphic and wider communication skills, social awareness and team work (including combating racial and gender prejudice), scientific and technical literacy, industrial and economic understanding, environmental activism, "life skills" and vocational training. This litany of virtue smacks of protesting too much, to the extent that it makes one wonder what the rest of the school is doing. Consequently, although it is obvious that aspects of all of these (and many other) educational experiences impinge on what is being learned through technology (in fact most subjects could include a similar list), it is essential that a rationalization takes place, and quickly.

If this rationalization results in a concentration on technological capability through problem solving, attention must be focused on these aspects and the complexity of both understanding a process view of technology education and the evaluation and assessment of its outcomes. Moreover, the implementation of the work must not be understated.

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