

Philosophy and Engineering Education; should teachers have a philosophy of Education?

Dr. John Heywood, Trinity College-Dublin

John Heywood is professorial Fellow Emeritus of Trinity College Dublin- The University of Dublin. He is a Fellow of ASEE and Life Fellow of IEEE. He has special interest in education for the professions and the role of professions in society. He is author of Engineering Education, research and development in Curriculum and Instruction. His most recent book is The Assessment of learning in Engineering Education. Practice and Policy.

Philosophy and Engineering Education: Should teachers have a Philosophy of Education?

Abstract. Arguments for engineering educators having a formalated philosophy of engineering education are presented. The perspectives that a person takes to moral dilemmas will be driven by the beliefs they have about the nature of morality and truth. Similarly, the beliefs that a person has about the content of the curriculum, instruction and learning will, in all likelihood be founded on one of the great 'isms of philosophy. A discussion of the debate that followed the publication of the proposed revision of the ABET criteria is used to illustrate the argument. As would be expected at a conference such debates are conducted at a "surface" level when they need to be conducted at a "depth" level. But this cannot happen without every engineering educator being versed in the philosophies that these different positions embrace. It is doubtful if hard and fast positions would then be maintained, and it would be strange if there was no renewal of the curriculum with an attendant restructuring. Such is the need for professional training in pedagogy in which educators are given the opportunity to explore a variety of philosophies, and learning approaches.

Why teachers should have a defensible philosophy of education.

Since philosophy encompasses the belief system of the teacher it follows, that every teacher should have a defensible philosophy of education. The "something" that turns our beliefs (attitudes and values) into action, that is the methods of teaching we use, and the content too which we subscribe, is what we call "philosophy." All of us have a philosophical disposition, some weak, some strong. Since engineering educators are teachers, and since their philosophy drives their educational activities, its curriculum, delivery and evaluation, it is right that no less should be expected of them: namely, that they have a defensible philosophy.

As Sherren and Long pointed out in *Engineering Education* engineering educators are likely to find that their beliefs, explicit or implicit, and values are grounded in one of the great ism's of philosophy e.g. realism, pragmatism, idealism and naturalism [1]). In the current literature of engineering education many authors claim to be constructivists- a variant of empiricism [2].

Again, at the 1979 ASEE/IEEE Frontiers in Education Conference two industrialists G. W. Sinclair and W. Tilston argued that the failure to achieve the goals of engineering education was because it lacked a proper philosophical base [3] An alternative position arises from the view that since engineering education is simply the application of science (mainly physics) to the solution of practical problems, its philosophical bases are to be found in the philosophy of science education for which a significant literature exists (eg. [2]; [4]). Whilst there is a strong case for examining that literature in respect of teaching the applied sciences, there is an equally substantial literature that shows that engineering is something more than the application of science to the solution of problems. Among the differences being that engineers think in a different way to scientists (e.g. [5]; [6]).

Within the practice of engineering different philosophies lead to different perspectives on ethical issues. For example "realists" take a "correspondence" theory of truth; that is, a statement is true if it corresponds to a state of affairs independent of the statement. In contrast constructivists who are also relativists (they need not be relativists) take a "coherent" theory

of truth, that is a statement is true if it coheres or fits with other statements that are true. “Truth, they will claim, is constructed by human beings within the societies in which they live. In morality, therefore, there is no search for any reality beyond the moral rules human beings create and live by” [7]. Realists on the other hand argue that there is only one set of truths and that the task of moral philosophy is the search for those truths. To defend a moral position one has to be sure about the basis of ones beliefs, that is, they have to be defensible.

Exactly the same applies to reasoning about educational issues which often does not extend very much beyond the trivial when compared to the knowledge that is available. The recent debate about the proposed revision of the ABET criteria falls into this category, and illustrates the failure of the engineering fraternity to have a fundamental debate about the aims of engineering education that is other than a set of warring opinions. But if the participants in any debate have not understood the philosophical basis of their opinions that is to be expected. Prior knowledge is a pre-requisite to understanding any issue, hence the need for engineering educators to have a defensible philosophy of education. This point will be illustrated by reference to the debate about ABET’s proposals to change their criteria.

The ABET debate:

Two dimensions of this debate will be considered. The first, for want of a better term is called “technical.” It is about the design of the criteria, and need to attend to “meaning.” It justifies attention to the precepts of analytic philosophy and the meaning of statements. The second dimension might best be described by the term “philosophical.” It seeks to understand the belief systems that drive the curriculum debate, for it is about what content the new regulations allow and what content they do not allow.

The technical dimension: language and the meaning of things

Although the average member of the public, and for the most part that is you and I, would not want to engage in the abstract conversations of philosophers on language, some things have trickled down into the public arena. For example, the analytic philosophers of the twentieth century have made us increasingly aware of the need to clarify meaning: We know that if the questions we set in a public examination are unclear there is the possibility that we will be taken to court. More pertinently we know that if an instruction we give to a technician is misunderstood, and leads to an accident, that we are ultimately responsible for what happened. So we need to check that our instructions are understood and not misunderstood. Nowhere does the problem of meaning raise its ugly head than in the interpretation of statistics, particularly those to be found in newspapers.

Since the year 2000 engineering educators in the United States have been required by ABET to ensure that the programs they teach will achieve certain specified outcomes. Before they were introduced in the year 2000 engineering educators were able to attend meetings that clarified the meaning of these outcomes. Two engineering educators Yokomoto and Bostwick argued among other things that “secondary meanings of some words are sometimes used, such as using the term ‘criteria’ to describe the level of performance that students must achieve and ‘outcomes’ to describe the learning behaviours students must demonstrate” [8] A more common definition of ‘outcome’ is ‘result’ or ‘consequence’, and anyone attaching that meaning to the word will surely become confused in any discussion about writing measurable outcomes. Yokomoto and Bostwick said that the aims listed by ABET were

considered to be too broad to be assessed directly, and in the tradition of *The Taxonomy of Educational Objectives* they recommended that those aims should be broken down into smaller more measurable units [9]. The essence of their argument was that accrediting agencies should explain the terms used, and use them consistently, and to this end they made a distinction between course outcomes and course instructional objectives. Again such distinctions are debatable.

More generally an important aspect of language is its use in the expression of the emotions. One effect of the outcomes movement is that it has removed many words from the language of the academic common room. One term that has many meanings and is not easy to define is “motivation” yet, it is very much a driver of our teaching – the desire to motivate both students and teachers. It is very much the language of the psychology of learning- readiness to learn, reinforcement, transfer of learning, critical thinking, problem solving, and so on. The ABET debate certainly generated many emotions.

From the outside looking in

While ABET is an American organization in recent years its influence has extended beyond its borders and some countries are using its accreditation mechanisms. There is, therefore, an international interest in the bases of the accreditation criteria. That is the justification for an outsider, although a member of ASEE using ABET to exemplify the central thesis of this paper, namely that every teacher should have a defensible philosophy of education. For this reason an American paradigm developed by Michael Schiro [10] which reflects developments in school education in the US, and the philosophies that have driven them, is used as a focus for the argument. Schiro distinguishes between scholar academic, social efficiency, learner centred, and social reconstruction ideologies. I argue that the ABET debate, as I was able to observe it, was a conflict between different ideologies.

Ideologies behind the debate

(1) The scholar academic ideology

John Eggleston, an English educational sociologist and technical educator, has described a “received” paradigm of the curriculum which helps to introduce Schiro’s scholar academic ideology [11]. Knowledge in this curriculum paradigm is received and accepted as given. It is non-negotiable, non-dialectic, and co-sensual. Knowledge is something that is given, and is that which should be transmitted to children. Through it the accumulated wisdom of a culture is transmitted.

Eggleston’s paradigm is similar to the “Scholar Academic ideology” proposed by Schiro. “Scholar academics” writes Schiro, “assume that the academic disciplines, the world of the intellect, and the world of knowledge are loosely equivalent. The central task of education is taken to be the extension of the components of this equivalence, both on the cultural level as reflected in the discovery of new truth, and on the individual level, as reflected in the enculturation of individuals into civilization’s accumulated knowledge and ways of knowing” [12].

Jerome Bruner a distinguished American psychologist wrote: “A body of knowledge enshrined in a university faculty and embodied in a series of authoritative volumes is the result of much prior intellectual activity. To instruct someone in these disciplines is

not a matter of getting him to commit results to mind. Rather it is to teach him to participate in the process that makes possible the establishment of knowledge. We teach a subject not to produce little living libraries on that subject, but rather to get a student to think mathematically for himself, to consider matters as historian does, to take part in the process of knowledge-getting. Knowing is a process, not a product” [13].

The process that makes possible the establishment of knowledge is, in this ideology, what is understood by learning. For each school subject there must be a corresponding academic discipline as represented in the universities. Because the disciplines are dynamic they are concerned as much with “what will be” as with “what was” [14]. That this is so, is illustrated by the great curriculum projects that were undertaken in the sixties and seventies because in the U.S. teachers did not have the resources to undertake such developments which normally be considered to be part of the role of the teacher functioning in this ideology [15].

The scholar academic ideology is teacher centred. Information is conveyed to the mind which reasons about it, as required. Learning is the result of teaching [16]. Because each discipline has within it, its own theory of learning, generalized theories of learning have no place in the design of instruction.

It is not unreasonable to suggest that the majority of engineering educators would hold this ideology to be true. But, they have had to accept modifications to meet the requirements of accreditation authorities, sometimes prompted by politicians who are motivated by the “social efficiency ideology.”

- (2) **The social efficiency ideology** requires that the curriculum serves utilitarian purposes, namely the creation of wealth. Institutions have to be run like businesses: therefore, the curriculum has to be seen to be providing measurable outcomes in the form of objectives now called outcomes. In this paradigm the teacher’s role is to guide (manage, direct and supervise) the learner to achieve the outcomes (or terminal performances) required. Knowledge is defined behaviourally in terms of what a student “will be able to do,” as a result of learning. There is little concern for the child except for the potential they have as adults, and the inputs they give to the economy. Evaluation and assessment are central to the vision of this ideology.

It is the prevailing curriculum ideology in engineering education, as seen for example in the current ABET criteria. The social efficiency ideology has its origins in the objectives movement and the curriculum model of Ralph Tyler [17]. But, Schiro also considers that educators who subscribe to this ideology value a programmed curriculum, and the psychology underpinning it to be found in behavioural psychology, as for example that of B. F. Skinner. In engineering education it can be seen in the systems of mastery learning and personalised instruction that were experimented with in the 1960’s and 1970’s [18; [19]; [20].

While behavioural psychology was replaced by cognitive psychology it is relevant to note that there are many politicians and administrators who believe that computer assisted learning might come to be used to replace lectures which are considered to be conveyors of the same knowledge that is to be found in textbooks. Evaluation is very important to those who hold this ideology.

There are tensions between those who adhere to the scholar academic ideology as well as those who adhere to the learning centred and social reconstruction ideologies and the social efficiency ideology.

- (3) **The learning centred ideology** is in stark contrast to the social efficiency ideology. The child is at the centre of, and has a profound influence on the curriculum process. This ideology is associated with the educational philosophy of John Dewey. It believes that the learning centred school would be totally different to the traditional school. The Montessori and Reggio Emilia schools are cited as examples. They are activity based.

Learner centred schools are based on natural developmental growth rather than in demands external to them. “Individuals grow and learn intellectually, socially, emotionally and physically in their own unique and idiosyncratic ways and at their own individual rates rather than at a uniform manner” (Schiro, p 111). In the UK the learner centred approach was espoused in the Plowden report (Plowden, 1967).

The philosophy that underpins these schools is constructivism. The schools and curriculum are designed to produce students who are “self-activated makers of meaning, as actively self-propelled agents of their own growth, and not as passive organisms to be filled or moulded by agents outside themselves [21]. Learning moves from the concrete to the abstract. The idea of active and passive learning has become part of the vocabulary of higher education, not in the sense of organizing an institution for active learning, but in the sense of teachers organizing and managing their classrooms for student centred active learning. The relationship between the teacher and the student is quite different to that established by educators from either the scholar academic or social efficiency ideologies, and Cowan [22] argues, to be preferred.

In addition to establishing the environment for learning the teacher has the functions of observing and diagnosing individual needs and interests, and facilitating the growth of the students in their care. Learning Centred educators are opposed to the psychometric view of testing as expressed by social efficiency educators. Standardized tests are anathema to learner centred educators. It is assumed that children’s work is best assessed by children themselves hence the importance of learning logs and journals. Some engineering educators are advocates of peer and self-assessment as well as the use of portfolios and journals [23]; [24]; [25]; [26].

Because knowledge is created by individuals as they interact with their environment, the objectives of a learner centred education are statements of the experiences the

student should have. This view brings learner centred educators into conflict with those who believe that the objectives of an education are its measurable outcomes which is the case with ABET and other systems where administrators and politicians require measures of efficiency.

- (4) **The social reconstruction ideology** takes the view that, since society is doomed because its institutions are incapable of solving the social problems with which it is faced, education is concerned with reconstructing society. Philosophically this ideology has its foundations in John Dewey's *Reconstruction in Philosophy* and *Democracy and Education* [27; [28]. According to Schiro the social reconstruction ideology was brought to life through a split in the Progressive Education Association [29]. As might be expected it took a social constructivist view of knowledge – knowledge is relative. The purpose of teaching is to stimulate students to reconstruct themselves so that they can help reconstruct society. Some authors see teaching as a subversive activity [30].

The principle methods of teaching are the “discussion” and “experience” group methods. In the “discussion” method the teacher elicits “from the students meanings that they have already stored up so that they may subject those meanings to a testing and verifying, reordering reclassifying, modifying and extending process” (Postman and Weingartner cited by Schiro, [31]). In this way a transformation of and reconstruction of knowledge occurs in response to the group process. The experience method places “the students in an environment where they encounter a social crisis and learn from those who usually function in that environment” [32]. The teacher in this technique becomes colleague and friend.

Schiro writes “human experience, education truth and knowledge are socially defined. Human experience is believed to be fundamentally shaped by cultural factors; meaning in people’s lives is defined in terms of their relationship to society. Education is viewed as a function of the society that supports it and is defined in the context of a particular culture. Truth and knowledge are defined by cultural assumptions: they are idiosyncratic to each society and testable according to criteria based in social consensus rather than empiricism or logic” [33].

While the view of those who hold to this ideology may seem way outside the scope of engineering education, is it? Clearly the answer is yes since some engineering educators have promoted the cause of peace engineering [34], and social justice [35] In any event it is unlikely that engineering educators would disagree with the view that today the primary purpose of engineering is to improve the lot of individuals and the society in which they live. Central to the achievement of that goal is engineering design which as Bucciarelli [36] shows, is a social activity. It reconstructs society, apparently with little attention to the consequences [37]. Social reconstruction educators take the view that while “man is shaped by society and man can shape society [...] Individuals must first reconstruct themselves before they can reconstruct society” [38].

The implications of this ideology for the engineering curriculum and its teaching are profound

Discussion

Four ideologies that broadly categorize teachers by the beliefs they have about the purposes of education, the nature of knowledge, how students learn, and in consequence the curriculum have been described. They apply equally to engineering educators. These philosophies are the drivers of the teaching and learning strategies adopted. They account for some of the tensions that exist within the engineering education community, and when deeply held are powerful resistors of change. Change is only possible when a 'deep' understanding of these different philosophies is held by all the participants. In that circumstance a rational debate is possible, and the merits or otherwise of a proposed change can be evaluated. It is asserted here that many of the debates about engineering education are conducted at a "surface" level which prevents understanding of different points of view, and causes any "depth" discussion of the aims of engineering education to be neglected. To enable "depth" discussion to take place it is essential that the educator has a defensible theories of learning and philosophy.

There are problems with each of the ideologies. It is also doubtful if any one of the ideologies can be sustained on its own. For example, the scholar academic ideology is not concerned with learning. Curriculum concerns other than those with the discipline do not contribute to the essence of the curriculum. The role of the teacher is as a transmitter and mediator of the knowledge contained in the discipline which the student remembers, and uses to perform mental operations. It is difficult to see how this position can be sustained in the light of present day understandings of the factors that influence learning. Furst, one of the authors of *The Taxonomy of Educational Objectives* argues that every teacher should have defensible theory of learning [39]. A view from which it is difficult not to assent.

Williams [40] whose analysis of the shortcomings of engineering education was little debated, argued that the fragmentation of engineering into a number of specialisms had deprived the curriculum of anything that was specifically engineering. Is there something that is a specifically an engineering curriculum? Questions of this nature cannot be answered without an understanding of the philosophical issues involved [41]. A key question is how is a discipline formed? If the engineering discipline is simply the application of science to practical problems, should it take note of Trevelyan's argument that the exercise is pointless unless the practice of engineers is taken into account? If it is, then notice has to be taken of the affective domain, and that is prohibited by the scholar academic ideology, and ignored by those who follow the social efficiency ideology, even though the authors of the cognitive *Taxonomy* also wrote a taxonomy for the affective domain [42] Neither can this position be sustained, for there is substantial evidence of the importance of the affective domain in the engineering literature [43]; [44]. Both the learner centred and social reconstruction ideologies embrace the affective domain in their attention to the whole person.

Schiro's description of the social efficiency ideology does not mention specifically the idea of competency although it may be inferred. The use of the term "competency" by engineering educators seems to go in phases. Currently some engineering educators are using it to describe outcomes, but little note seems have been taken of two views of competency that have been explored in detail in medical education [45] The first asserts that the competency is within the person and may therefore, be taught. That is consistent with the scholar academic

ideology. The opposite view is that engineering competency is context dependent [46]; [47] which is consistent with the social reconstruction ideology.

If engineering is about improving the world in which we live, then engineering educators can hardly avoid the premises of the social reconstruction ideology. There are, for example, many illustrations of courses that involve students in solving engineering problems for developing nations (e.g. [48]). It may also be argued that engineering designers are necessarily members of this category, but so they are of other categories. It is difficult to sustain the view that a professional engineering educator can be a member of one category alone.

At the 2015 and 2016 ASEE conferences ABET's proposed revisions of their criteria were hotly debated. A first reaction was to perceive it as a conflict between those who advocated a more liberal education for engineers and those who did not. It seems more profitable to view this debate as a demonstration of a tension between 3 ideologies viz. ABET as representative of social efficiency model, Dr Riley who took a lead role for the critics as representative social reconstruction ideology [35] and the remainder, many of whom would probably have belonged to the scholar academic group. As would be expected at a conference such debates are conducted at a "surface" level when they need to be conducted at a "depth" level. But this cannot happen without every engineering educator being versed in the philosophies that these different positions embrace. It is doubtful if hard and fast positions would then be maintained, and it would be strange if there was no renewal of the curriculum with an attendant restructuring. Such is the need for professional training in pedagogy in which educators are given the opportunity to explore a variety of philosophies, and learning approaches.

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