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Empowering Professional Teaching in Engineering

Sustaining the Scholarship of Teaching

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SYNTHESIS LECTURES ON ENGINEERING #29

ABSTRACT

Each one of us has views about education, how discipline should function, how individuals learn, how they should be motivated, what intelligence is, and the structures (content and subjects) of the curriculum. Perhaps the most important beliefs that (beginning) teachers bring with them are their notions about what constitutes "good teaching". The scholarship of teaching requires that (beginning) teachers should examine (evaluate) these views in the light of knowledge currently available about the curriculum and instruction, and decide their future actions on the basis of that analysis. Such evaluations are best undertaken when classrooms are treated as laboratories of inquiry (research) where teachers establish what works best for them.

Two instructor centred and two learner centred philosophies of knowledge, curriculum and instruction are used to discern the fundamental (basic) questions that engineering educators should answer in respect of their own beliefs and practice. They point to a series of classroom activities that will enable them to challenge their own beliefs, and at the same time affirm, develop, or change their philosophies of knowledge, curriculum and instruction.

KEYWORDS

accountability, action research, active learning, advanced organiser, affective, animation, answerability, assessment, attitudes, beginning engineering educators, code of ethics, cognitive dissonance, communication, community, competence, complexity, cognitive organisation, curriculum (design, paradigms, process), concept (cartoons, clusters, inventories, key, maps, learning), content (syllabus), convergent, creativity, critical thinking, debates, decision making, design, diagnosis, discipline (s) (of knowledge), discovery, divergent, educational connoisseurship, evaluation, examinations (tests) ,examples, experts, expository instruction, instructional design, expressive activities, grading, heuristic(s), guided design, inquiry based learning, instructor centred, intellectual development, intelligence (applied, emotional, practical, academic), interdisciplinary, kinesthetic activities, knowledge (fields of, forms of, prior procedural, tacit, knowing), laboratory work, language(s), learner, learner centred, learning (active, independent, modes of, perceptual, surface, deep, styles of), lesson planning, lectures, listening, mediating response, memory, mind maps, misperception, mock trials, motivation, negotiate(ion),novice(s), objectives (behavioral/focussing), originality, outcomes, principles, professionalism (restricted/extended), reflection, Reflective Judgment Interview, peer teaching/review, personality types, philosophies related to engineering education, Polya, practical reflection, qualitative thinking, questions, questioning, scholar academic ideology, scholarship of teaching, social efficiency ideology, social reconstruction ideology, stages of development, taxonomies, teaching as research, tests, testing

Contents

Foreword

Tertiary education has experienced both rapid evolution and several significant changes in mission since the Second World War. Much of the technologically advanced world has become increasingly reliant on tertiary education as a supplier of engineers and creative thinkers of all types. At the same time, this utilitarian view of education has transformed the public view of education, which more often than not these days is seen as a process through which graduates are "produced", or as a "service" provided to an intellectual elite, which equips them for a successful and highly paid career. The view that education is about developing the individual and enhancing their intellectual capacity in the context of an academic environment which stimulated debate and enquiry has largely fallen by the wayside.

In this new landscape academic teachers are expected to perform research and teaching of the highest quality. High expectations in regard to teaching excellence has ben increasingly emphasised in the Nordic Countries, where in many places ten full time weeks of formal training in the theory and practice of tertiary education is a prerequisite for appointment to a tenure track position. Even in the United States of America the expectations in regard to teaching have changed significantly, not least in response to Boyer's 1991 book "Scholarship Reconsidered: Priorities of the Professoriate".

Quality in higher education is also an increasingly prominent component of the political discourse surrounding tertiary education. This book makes a significant contribution to both academic staff development and teaching quality by drawing together over fifty years of work in the area of evidence based teaching practice. The reader gains both new perspectives on teaching and assessment practices and a model for sustainable practice and professional development as a university teacher. Academic practice is more than research, the educational mission to inspire future generations of scholars to engagement and excellence in science and engineering underpins the success of our technological society.

The model and resources offered here form part of a broader effort in which Professor Heywood, myself, the American Society for Engineering Education (ASEE) and the IEEE Education Society are engaged. The goal is to provide sustainable support for academic teaching practice and professional development combined with international levels of professional recognition linked to a range of activities that promote and enhance the "Teaching as Research"

model. This book is a vital resource in the pursuit of this goal, and it gives me great pleasure to have contributed in a small way to its conception and final form.

Arnold Pears
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July 2017

Preface and Introduction

At the 2016 ASEE/IEEE Frontiers in Education Conference (FIE) Professor Arnold Pears of Uppsala University in Sweden organized and led a one day workshop on teaching and assessment for beginning engineering educators and experienced engineering educators beginning to take an interest in teaching. I was privileged to lead the discussion on assessment. I noticed that several of the participants were experiencing the same difficulties that beginning school teachers experienced, and drafted some notes that I thought might be used in any future courses of this kind. Dr Mani Mina of Iowa State University with whom I had collaborated in presenting a blended on line course on, "The Human Side of Engineering" attended the workshop, and as a result of my notes it was decided that he would organize a professional development course on teaching and learning for his colleagues in the Departments of Electrical and Computer Engineering and Industrial Design. It would use the format of the previous course. In the event 16 lectures each of approximately 20 minutes duration were recorded, and followed four days later by hour long discussion seminars on the prior recorded topic. A print version was also made available. This book records the sixteen lectures with the associated notes which are of equal importance.

The first three journeys are constructed around the issue of accountability. To whom am I accountable, and for what? Many engineering educators experience a conflict between the demands of research and the requirements for teaching. Looked at from the perspective of professionalism, a person who enters engineering education acquires a dual responsibility for research and teaching. Irrespective of the demands for and recognition achieved by research, there is an obligation to be as effective as possible at teaching. By accepting the role of engineering educator an individual accepts that teaching is a professional activity, and has to choose between being a "restricted" or an "extended" professional. Professionals accept personal responsibility for the effectiveness of their teaching. How individuals can judge the effectiveness of their teaching is the subject of journeys and two and three. Journey 2 focuses on Eisner's technique of educational connoisseurship, and Journey 3 considers what the scholarship of teaching is, and argues that it is accomplished by treating the classroom as a laboratory for research and development. Effective teaching can only be sustained if that becomes the case. This requires an acknowledgement and understanding of that body of knowledge called "education." This book is one way of introducing that body of knowledge.

Each one of us has views about education, how discipline should function, how individuals learn, how they should be motivated, what intelligence is, and the structures (content and subjects) of the curriculum. Perhaps the most important belief that beginning teachers bring with them are their beliefs about what constitutes "good teaching". The scholarship of teaching

requires that beginning teachers should examine these views in the light of knowledge currently available about the curriculum and instruction.

Since there is no single theory of the curriculum or instruction various attempts have been made to classify the different ideologies that represent the diversity of views among engineering educators.. In Britain John Eggleston distinguished between "received", "reflexive", and "restructuring" paradigms of the curriculum. In the United States Michael Schiro distinguished between four ideologies that he called "Scholar Academic", "Social Efficiency", "Centred", and "Social reconstruction". The philosophies that support these ideologies also support different approaches to teaching. Michael Schiro reports one research that shows that teachers change their beliefs during their teaching careers.

Journey 4 begins with the social efficiency ideology for the reason that it is this ideology that governs much educational thinking at the present time, and in engineering in particular. It begins with a brief account of the "objectives" movement leading to a discussion of the "Taxonomy of Educational Objectives", and objections to the objectives approach by Eisner. The role of objectives in planning and instruction is considered. The journey ends with an attempt to reconcile the behavioral objectives approach with that of its opponents.

The fifth Journey considers the problem of problem solving. Should it be taught as a separate skill or simply learnt by total immersion in the subject? Those who hold the former view are representative of the social efficiency ideology. A distinction may be made between those who believe problem solving should be taught within normal course structures, and those who believe it should be taught in separate courses. The best known example of the latter is the Problem Based Learning approach developed by Don Woods at McMaster University. There are many examples of the former where teachers use a simple problem solving heuristic like that suggested by Polya as part of their instructional approach. It is with this approach that Journey 5 is primarily concerned. It shows just how difficult the curriculum process is, and how "time" is required for learning.

Journey 6 is a continuation of Journey 5 and looks at problem solving heuristics in more detail, and in particular at Wales, Stager and Nardi's "Guided Design" model. Studies of expert and novice behavior reported in Journey 5 and this journey, showed there was something more to problem solving in engineering than the learning of a range of heuristics, and that there was a need for qualitative as well as quantitative understanding. Engineers have to learn a number of languages if they are to successfully engage in engineering problem solving. It is concluded that there is a case for a separate category of problem solving in any statement of objectives.

These three Journeys (4, 5, 6) highlighted the importance of assessment on learning. They showed how changing the conditions of learning impact on the role of the teacher. They also pointed to questions about students. What should instructors know about their students? How do teacher beliefs impact on what they do? For many teachers these beliefs may be described as belonging to the scholar academic ideology, or Eggleston's received curriculum.

Journey 7 introduces the scholar academic ideology. In a received curriculum knowledge is received and accepted as given. It is non-negotiable, non-dialectic, and consensual. It is the basis of the "disciplines" view of the curriculum. It is about the enculturation of individuals into civilization's accumulated knowledge and ways of knowing. But, each discipline seeks to mould students in its own image and likeness. Many academics including engineering educators would associate themselves with this ideology. It is teacher centred. Jerome Bruner who is associated with this ideology is of particular interest because of his promotion of discovery (now often called inquiry) based learning. The advantages and disadvantages of this kind of learning are considered. The journey ends with a brief section headed by the question "Is engineering a discipline?"

Associated with Jerome Bruner is the idea of "spiral curriculum" in which concepts are revisited on several occasions during the course, but at deeper levels of abstraction. Journey 8 begins with a discussion of this model. It raises questions about how engineering is related to the school curriculum, and an example of a primary school project in which children in the age range 5 to 13 engaged in min-company activities is given Those who sponsored the activity believed that entrepreneurs would only emerge if attention was paid to the development of entrepreneurial skills throughout the age range of schooling. The Spiral curriculum also relates to intellectual development. The significance of Piaget's work, and studies of intellectual development in higher education by Perry, and King and Kitchener are considered.

Bruner's discovery learning was criticised by among others David Ausubel. Although a very strong advocate of expository learning, he was concerned with the way in which learning is organized. He is noted for the concept of the "advanced organizer". Its use in instructional practice begins Journey 9. The importance of prior knowledge in learning and the development of memory is emphasized. The journey ends with a discussion or cognitive organization and mediating responses. Much care needs to be taken in the preface to instruction if that instruction is to be meaningful to students

Meaningful learning requires that students understand concepts. The role of concepts in learning, and in particular the work of Robert Gagné is the subject matter of Journeys 10 and 11. One of the reasons why students find qualitative thinking in engineering difficult is that they have an inadequate understanding of concepts to the extent that they are misperceived. How to deal with misconceptions is a major problem for instructors. The most common heuristic used in instruction is the "example". Research shows that some approaches to the use of examples are better than others. Learning concepts often takes time and many teachers do not take a step by step approach because of beliefs about the need to cover the syllabus. This seems to be a central issue in teaching. It seems probable that a lot of the difficulties experienced by engineering students, especially in the freshmen year, arise from a shortage of time to assimilate the learning of the concepts being presented especially when they are complex. Journey 11 gives a brief introduction to the teaching of complex and fuzzy concepts.

The focus of Journey 12 is on the learner centred ideology. It 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. Like the social reconstruction ideology it is associated with the philosophy of John Dewey. In this ideology the student is a self-activated maker of meaning. Learning moves from the concrete to the abstract. Learning centred educators know a lot about their students. It is argued that engineering educators should have at least a knowledge of their students learning styles. The journey draws attention to convergent and divergent thinking because there is strong argument that engineering students are often taught in ways that are antipathetic to creative thinking. Following discussion of Kolb's theory of experiential learning and the Felder-Solomon Index of Learning Styles, the journey concludes with a brief commentary on the relation between temperament and learning styles. It is concluded that studies of learning styles and the temperaments of students can provide educators with insights into student learning and instruction.

Those who follow the learning centred ideology do not like psychometric testing or formal examinations. Yet most of us have beliefs about intelligence and its role in learning. Journeys 13, 14, and 15 deal with issues surrounding the concept of intelligence. Journey 13 begins with a brief discussion of the impact that intelligence testing has had on school systems. It is agreed that tests of general mental ability are found to be relatively good predictors of job performance. But multiple methods of assessment are to be preferred to a unitary instrument. Journey 14 begins with a description of the nature-nurture controversy and concludes that we should think about "Nature and Nurture" not "Nature versus Nurture".

Just as engineering educators should have a view about intelligence so they should have a view about competence. Two views of competence are presented. They have profound consequences for the design of the curriculum and instruction. The role of communication is highlighted, but doubt is cast on the methods used to teach communication as a means of achieving the goals that are required. The view is expressed that the curriculum should be perceived in terms of intellectual and personal development that continues throughout life. That places considerable responsibility on industry for the development of their personnel which most organizations do not seem to accept.

Two alternative theories of intelligence are presented in Journey 15. The first is Howard Gardener's theory of multiple intelligences, and the second, Robert Sternberg's Triarchic Theory of intelligence. Attention is given to implicit theories of intelligence. Sternberg is also important for engineering education because of his concept of "practical intelligence." The journey ends with a discussion of emotional intelligence. These journeys show that not only teaching but policy making in respect of the curriculum, benefit if we have a wide ranging understanding of student behavior.

The final journey is a commentary on the social reconstruction ideology. It considers that society is doomed because its institutions are incapable of solving the social problems with which it is faced. Therefore, education has to concern it with the reconstruction of society. Like the

learning centred ideology it is based on a social constructivist view of knowledge. The principle methods of teaching are "discussion" and "experience" group methods. In education Karl Smith has encouraged "constructive controversy". Other methods are "debates" and "mock trials". The journey ends with a case study. It is concluded that since learning is shared activity the least an instructor can do to foster relationships is to share his/her scholarly activity with his/her students.

John Heywood
October 2017

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John Heywood
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