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The Human Side of Engineering

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The Human Side of Engineering

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ABSTRACT

While in many university courses attention is given to the human side, as opposed to the technical side of engineering, it is by and large an afterthought. Engineering is, however, a technical, social, and personal activity. Several studies show that engineering is a community activity of professionals in which communication is central to the engineering task. Increasingly, technology impacts everyone in society. Acting as a professional community, engineers have an awesome power to influence society but they can only act for the common good if they understand the nature of our society. To achieve such understanding they have to understand themselves. This book is about understanding ourselves in order to understand others, and understanding others in order to understand ourselves in the context of engineering and the society it serves. To achieve this understanding this book takes the reader on 12 intellectual journeys that frame the big questions confronting the engineering professions.

KEYWORDS

agency, assumptions, change, common good, communication, community, contractualism, constructivism, consequentialism, curriculum, duty, development, engineering, engineering education, enterprise, epistemology, ethics, engineering ethics, fear, higher education, judgement, knowledge, language, learning, learning organization, life-long learning, management, mobility, morality, open-system, closed system, organization, the person, perception, philosophy, philosophy of engineering, professional, realism, reflection, responsibilities, rights, schema, self-management, social system, transfer of learning, team-work, technological literacy, truth, university, virtues, ways of thinking, work, workforce

Contents

Foreword xi

Preface and Introduction xvii
Notes xxi

Acknowledgments xxv

1 "It all Depends on What You Mean by..." 1
Notes 6

2 Thinking about Thinking 11
Notes 18

3 Things are not Always What They Seem 21
Notes 26

4 Meaning—True or False: Real or Imagined 31
Notes 34

5 From Perception to Self-Perception and a Little Management En-route 37
Appendix 45
Notes 47

6 Sharing Problems: Living in Communities 53
Notes 56

7 Thinking about Making a Good Engineer Possible 59
Notes 66

8 Aspiration in Engineering 71
Notes 76

9 Preparing for the Future: Individuals and Organizations 81
Notes 88

10 Changing Us: Changing Society 93
Notes 99

11 Journey's End: A New Beginning? 109
Notes 117

12 Questioning our Assumptions: Adaptability and Change 119
Notes 127

Author's Biography 131

Author Index 133

Subject Index 137

Foreword

THE BIG PICTURE

This book is a series of essays that were originally created by John Heywood for a seminar at Iowa State University—Electrical Engineering EE510M—that I created during the Fall 2013. Faculty and students from different perspectives, disciplines, and departments attended and contributed to the seminar class. This version of "the Journeys," as his explorations in the seminars were called, is a result of interactive participation, discussion, and feedback from the followers of the seminar, and finally the discussions between John and I. The journeys are explorations into the multidimensional and connected world of engineering, technology, and society. They invite the reader to explore the same territories and find their own answers, not those of a text book.

I thought it would be of value to provide the story of how these journeys started, what were the goals, objectives, and hopes that we I had when we embarked on this project. Hopefully, this will help you, the reader, to examine your perspectives and belief structures, and reflect on your fields of interest as it helped us and our friends, associates, and colleagues examine ours. We hope that readers will be encouraged to participate in more constructive dialogues and reflective activities about engineering and its purposes and, in consequence, engineering education. As John says at the end of the first journey "We […] are taking a series of journeys so we may better reflect on who and what we are as individuals and engineers within a society that is becoming increasingly complex."

THE SEMINAR CLASS

The idea for the seminar was the result of a very successful session that we did in the Spring of 2013 in the first class of electrical engineering [Electrical Engineering (EE185)] in our department. Because I had for some time used student reflections to monitor their experience and provide them with a method of self-evaluation I thought their development would be enhanced if they were enabled to engage in dialogue with an outside scholar so I asked John if he would meet with the class via Skype.

A week before the meetings, I introduced John and his ideas and writings to the class. For that week in EE185 we discussed who John is and students read about him by reading his memories of 50 years of being in IEEE (on the IEEE History website). The students then created a set of questions for him to answer. The questions were sent to John a few days before the meeting. On the day of the Skype meeting, he answered these and in dialogue with the students other questions put to him by them. The students not only liked the session but also kept asking to have

more sessions like that. In particular, they wanted to have more sessions with John. This session was so successful and students loved it to so much that I thought it would be even better if we could engage higher-level students, so we decided to do a seminar class with a new audience and create more in-depth discussions.

THE BEGINNING

Later that year, at ASEE's annual meeting (Atlanta, Georgia, 2013) we reviewed what had happened and considered how we could have a seminar class on the subject of engineering pedagogy and philosophy, promote discussion and debate within in them, and record the participants' reflections on them. John had the vision that we could bring the self, the person as an agent into the discussions and help the participants realize how to create their own journey in critical thinking, personal philosophy, and pedagogy. Eventually, he decided to create a few essays to trigger discussion that would help a selected group of faculty and senior students to debate, think, discuss, and appreciate the role of the humanities and social sciences in engineering and engineering education as a means of reflective practice.

When I returned from the conference the first thing I did was to visit the undergraduate office at Iowa State University Department of Electrical and Computer Engineering. I asked the Director Vicky Thorland-Oster the following: "I would like to make a class for Fall 2013 on Critical Reflections on Engineering, Engineering pedagogy, and philosophy, can you help me with that?" Vicky paused, looked at me, and said that the idea is great but we cannot create a class unless the curriculum committee approves it. This was not possible since the committee did not have meetings during the summer of 2013. But I had to make it happen! This was so special to us that we had to get it done. We just had to….

To make the seminar happen within the constraints of university bureaucracy, I decided to go through the regular academic system and create a special topic class. Since I am a member of the Faculty of Electrical Engineering in the Electromagnetic area, I used a special topic class for the Fall 2013 semester called EE510M. The class was officially (according to the Iowa State University catalog) a special topic class with the following title "EE510M: Special topics on Electromagnetism." John mentioned that since 50 or more years ago he had worked on ionospheric research in industry, this may fit! While this was a real stretch, it was the only way that we could have a class in the time that we had. After the class was created I began to invite people to participate. In order to be more descriptive about the seminar class we decided to adapt the title to "Critical Reflections on Engineering and Engineering Pedagogy". The Journeys would focus on how we develop and find our own belief structures as individuals and educators in the context of engineering and technology.

CREATING A PLATFORM FOR THE DISCUSSIONS: THE JOURNEYS

John Heywood started to write his personal reflections in a set of essays called "the Journeys." In this development he led with his ideas and reflections on engineering, pedagogy, and develop-

ment of personal philosophy. John and I have been active members of the American Society for Engineering Education (ASEE) and in particular in its Technological and Engineering Literacy and Philosophy of Engineering (TELPhE) division. As a part of that group we believed that in order to enrich our efforts in engineering education and pedagogy we need to question our epistemology of what is engineering, our roles as educators, our value systems as engineers and engineering educators, and more especially as individuals. As we engage in these activities and discussions we end up developing a philosophy of engineering and engineering education driven by our personal philosophy. John started to write the Journeys for the class to review and discuss them with him at weekly session.

John Pritchard, graduate student, researcher, and good friend, would record via Skype, direct the sessions, and put them into the final form that would be posted on the website he created for this seminar series. Copies of the scripts, and the accompanying notes too which John attached great importance to, would also be made available so a participant could choose to view the Skype recording or read the script or use both. In so far as was possible, the Skype would take place on Mondays and a Skype seminar would follow on Fridays.

THE SEMINARS

The seminars were advertised during the middle to end of August 2013. Then they began on the first week of September 2013. We met every Friday afternoon from 2–3 pm (8–9 pm in Dublin), the essay and the readings having been posted earlier in the week. Those who wanted to attend would be in the class during the live Skype session with John. The sessions would start with questions and comments by the participants. Some of the questions were created and sent to John via email; the others were asked and discussed during the sessions.

Based on the discussions, suggestions, interactions, and feedback from the participants, John modified the Journeys, added items, clarified points, and included some of the participant's points of view in the revision of the text. The Journeys that are published in this book are the modified and finalized ones. We believe the modifications that came about through dialogue have improved and enriched the original Journeys since the final forms do reflect the interactions and discussion by the participants.

THE PARTICIPANTS AND SOME OBSERVATIONS

The class was divided into three groups:

1. those who attended the live sessions from undergraduate and graduate students (from the U.S. and other countries) from electrical and computer engineering. In addition, we had faculty of engineering, English, rhetoric, and physics attending the seminar class;

2. those who followed the reading and activities within the campus of Iowa State University. This group included some administrative staff from the Department and the office of Dean of engineering including Associate Deans. In addition, there were a number of faculty and

graduate students in engineering, sciences, English, philosophy who were following our activities via our website; and

3. finally, interested national and international colleagues and friends including some of members of Technological and Engineering Literacy and philosophy of Engineering Division of ASEE and others also followed some of the activities also via our website.

We received reflections, critiques, and ideas from many of our caring and kind colleagues and participants. They patiently helped us think and rethink the activities and discussions. The Journeys reflect the feedback from the attendees and patrons who were kind enough to communicate with us during the progress of the project and after the completion of the Journeys as a part of ongoing critique and discussions. In particular, we are very thankful to our special colleagues and friends in ASEE Technological and Engineering Literacy and Philosophy of Engineering Division including Professors Alan Cheville at Bucknell University and John Krupczak at Hope College.

The class was very successful, and I have received requests to organize more seminar series of this kind. The engagement of the participants and continuations of support, and requests for more of this kind of activity, showed that our efforts were needed and that they should be continued in many forms. When I reflect back on the class, I realized that in particular the class became an effective vehicle for all to reflect and think more deeply about their beliefs and perspectives in their field and their relationship to education. Finally, it helped all participants to advance their efforts to develop their own "philosophy". We began the class with the title of "Critical Reflections on Engineering and Engineering pedagogy," and somewhere during the first half of the seminar it became "Critical Reflections on Engineering, Engineering Pedagogy, and Philosophy."

One of the more interesting observations was the reaction of the engineering participants and followers of the Journeys. They were fundamentally different to those the other groups. Here are some of the more interesting questions put to us by the engineering group.

- "These are wonderful words: How do they help me be better educator?"
- "Knowing all of this is fine: How could it help me do better as an engineer?"
- "If engineering is taking action, doing and designing things, how does philosophy help me do it better?"
- "This is of great value and importance. We do not have anything like that in our curriculum, and it has worked well."
- "Do we really need to change anything in our education system? It seems to work."
- "The engineering curriculum is based on skills, math, physics, and all of engineering concepts and practice. If we engage in pedagogical and philosophical discussions, reflections, and debates, it could reduce the students' engineering knowledge base. We would then develop weak students."

- "What would industry think? Would they still hire our graduates?"

The following question summarizes the overall engineering participant's questions and concerns: "These are nice words, and great perspectives, but how can I apply it to engineering and engineering education?" In a way, the engineering team is looking for a summary and action items to help them with possible implementation.

To our surprise, the physics, math, and English participants did not have such questions. They tried to absorb, participate, and contribute. One may think physics and engineering are close, but physics members did not really ask the same types of questions and did not show the same concerns as those reflected in the above list. Generally, the physics members were much more accepting and integrated the ideas and discussions; they were not looking for action items. Why? We need to remember that physics is usually placed in the college of sciences and liberal studies, and that this field of study was historically called natural philosophy. It only changed to physics about the second half of 19th century. Thus, physics is likely to be closer to a philosophical perspective than engineering; the true essence of this issue and observation needs more exploration, however.

All in our team claimed that they had to read some of the journeys and parts of the Journeys more than once to really see the point and connection to their intentions. We recommend that the reader, having read the Foreword and the Preface, to first read the journeys in order to become comfortable with the style, and the way the notes are used to support the argument on the one hand, and on the other hand provide a bridge for further exploration. The Journeys are meant to make the reader think, wander, enjoy, question, and argue with the writer as did the participants in the exercise.

A NEED; A SPECTER OF SOMETHING MORE

Upon review and discussion John, I, and many of our colleagues believe that the experiences and insights gained by participants point toward a fundamental void in the engineering community and in particular the engineering education community. There seems to be a lack of dialogue, creative discussion, and philosophical examination of what engineering is. For example, "Why do we teach what we teach? What is needed? What should all engineers know?" These are questions of the utmost importance for the field and its educators. Currently, there are few forums for such discussions in the arena of engineering education. However, there seems to be a need of national and international venues for creating meaningful and visible dialogue and discussions on engineering, engineering pedagogy, and philosophy of engineering and engineering education.

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August 2016

Preface and Introduction

The title of this book, *The Human Side of Engineering* is both borrowed from and inspired by one of the outstanding books on management, Douglas McGregor's The *Human Side of Enterprise* published in 1960. It's theories X and Y continue to help us understand the behavior of individuals at work and the impact that organizations have on them (see Journey 5). While in many courses some attention is given to the human side of work, it is by and large an afterthought, for engineering is thought to be a technical and personal activity.

Journey 1 uses a model of a three-legged stool to offer an explanation of how engineering produces a technology. Engineering is seen to be a process and technology the product of that process. The base of the stool is where the process begins: it represents the mind of the engineer and the beliefs, attitudes, and values that it generates. From this mind, informed by the values of the society in which it exists, come the product designs intended to solve the problems with which it is presented. In an engineering company that information is conveyed by those concerned with marketing about products that can be changed or new products that seem to be required. The resulting design is fed to manufacturing, or the problem is sent to R & D and subsequently back to manufacturing resulting in a technology that impacts on the economy and society. All this is done in an organization which links together all the components in order to produce the technology. That organization comprises roles, humans, and technical and the task of management is to coordinate and integrate them [1]. Resulting from studies of engineers at work the Australian engineering educator James Trevelyan concluded that four major competences required by expert engineers are technical coordination, project management, negotiation, and teaching [2], none of which have anything to do with skill in engineering science and engineering design, but everything to do with working with human beings.

Much of what Trevelyan found Michael Youngman, Bob Oxtoby, Denis Monk, and I found in a study of engineers at work during the nineteen seventies [3]. Whereas we reported only on our research, Trevelyan provides a substantive guide to what students need to know to become expert engineers. Had it been published before these journeys I would certainly have referenced it on several occasions. But there is a great deal in common between the findings of Trevelyan's research and ours. Primarily, as my diagram in the first journey shows engineering is far more than a bench at things are designed, made and tested. We found that roles, however precisely defined, depend on interpersonal relationships for their effective functioning. This means that engineers have to have high level interpersonal skills, skills that engineers are not known to possess to any great degree, so it is assumed. One of the major complaints of industrialists in the UK and U.S. is that universities do not produce graduates who can communicate or work in groups [4]. Their technical abilities are not questioned.

In his search to understand engineering epistemology in the aircraft manufacturing industry, Walter Vincenti's reported that engineering is a community activity in "*What Engineers Know and How they Know It*" [5]. This community activity is largely informal. All the elements that Trevelyan highlight are present in the few short paragraphs that Vincenti devotes to explaining the way knowledge is exchanged, structured, and built upon.

Technology impacts on everyone from the richest to the poorest. Acting as a community engineers have an awesome power to influence society. But this can only be done if engineers understand the nature of this community. To achieve that understanding we have to understand ourselves. This book is about understanding ourselves in order to understand others and understanding others in order to understand ourselves. This is a problem that each one of us faces, engineer or not. At the same time it faces curriculum designers with a problem because the knowledge required to do this has to be drawn from a wide range of disciplines, as for example, sociology, psychology, literature, economics, philosophy, and theology, and that is by no means the end, especially if it is assumed that the way to obtain this knowledge is through study of these disciplines. Yet that is what the present approaches to university education that focus on the study of subject disciplines would require.

However, it is evident that in everyday living we obtain vast quantities of knowledge that we assemble and make judgements about or discard. It is equally evident that some of those judgements are not as informed as they should be. Consider voting behavior. I suggest that the view which has recently emerged, particularly in the UK, that those who are educated are better able to make political decisions than those who have had little education is without foundation. Be that as it may when we solve problems we generally bring knowledge from a variety of areas to bear on the problem much of it acquired haphazardly. If we are more systematic we explore many avenues before deciding to pursue a course of action or learning depth. That is what children do in their early years. They explore everything. Albert North Whitehead the mathematician philosopher calls this a stage of "romance" in his theory of rhythm in education [6]. Romance is necessarily one of transdisciplinarity [7] because it is a stage of exploration, a stage of discovery. He writes, "The stage of first apprehension (a stage of ferment). Education must essentially be a setting in order of a ferment already stirring in the mind: you cannot educate the mind *in vacuo*. In our conception of education we tend to confine it to the second stage of the cycle, namely precision. In this stage knowledge is not dominated by systematic procedure. Romantic emotion is essentially the excitement consequent on the transition from bare facts to first realisations of the import of their unexplored relationships."

So too is the final stage of generalization (synthesis) which is, "A return to romanticism with the added advantage of classified ideas and relevant technique."

Between these stages is one of precision (grammar) in which, "width of relationship is subordinated to exactness of formulation. It is the stage of grammar, the grammar of language and the grammar of science. It proceeds by forcing on the students' acceptance a given way of analysing the facts, bit by bit. New facts are added but they are the facts which fit into the analysis."

It is here that the language, which is the "style" of a particular subject, is learnt, and the interest found in the stage of romance turned into a search for expertise.

Whitehead does not expect the stage of romance to be one that is simply a collection of "scraps of information." In a lecture on the aims of education to mathematics teachers he said, "*Culture is activity of thought, and receptiveness to beauty and humane feeling. Scraps of information have nothing to do with it. A merely well informed man is the most useless bore on God's earth. What we should aim at producing*" are [*is*] persons [*men*] *who possess both culture and expert knowledge in some special direction. Their expert knowledge will give them ground to start from, and their culture will lead them as deep as philosophy and as high as art* [6, p. 1]. Education is then, "*the acquisition of the art of utilisation of knowledge*" [6, p. 6], and one of the functions of the stage of romance is to help the student find that "special direction." Looked at from the perspective of Whitehead's formal philosophy engineering and technology are creative activities. The stage of "romance" is not only one of discovery but of creative exploration [8]. It is a view that fits well with what an engineer seeks to do.

The intention of these journeys is that they should be a stage of romance. They are intended to create a debate as well as to inform. The extensive notes are designed as guides to further study and result from the debates that the journeys caused when they were delivered. They are a bridge between romance and precision and grammar.

The goals of the stage of "romance" relate to

- the motivation of students;
- how we know and learn. How our learning styles influence the way we learn;
- the exploration of our personal value systems;
- personal development; and
- practical experience with what is learned.

These journeys are explorations (Mani who organized them would prefer "reflections") of ourselves and organizations that have the purpose of helping you and I establish who and what we are as individuals, engineers and educators in a society that is becoming increasingly complex. The roads that I took were not always familiar and eventually they led to consideration of the "common good," and to the view that the basis of all professional study is a liberal education which I explore in the last but one and final journeys. My answer to those who asked Mani "how will it help me to do better as an engineer?"—is that good engineering is a community activity that depends on wisdom and skill in practical reasoning as it is often called. These journeys are essays in practical reason [9].

Notwithstanding the difficulty of summarizing short essays, I will engage in the task in the hope that it will be helpful. Journey 1 is about meaning and language. Through a brief analysis of the engineering processes involved in the making of a technology product we learn that engineers

have to speak many languages. At the end of this journey you are invited to participate in an activity that is a preparation for Journey 2 which is about perception, or about the meaning that reality has for you and I. At the same time, it shows the relevance of a philosophy of engineering that seeks to answer such questions as—"how and why do engineers differ from scientists and business people?"

The road widens and broadens our understanding of perception. Both Journeys 2 and 3 show that the boundaries between philosophy and psychology are often blurred. Journey 3 takes us past some of the best known illusions to the importance of personal relationships, and from there to how we handle the mass of information with which we are faced each day, and how the influence of past experience affects the way we solve problems, particularly engineering problems.

Journey 4 brings us to another blurred boundary, that between philosophy and sociology and their respective theories of knowledge. Our understanding of "how we know" and "how we learn" impact on our everyday behavior, and influence our attitudes, opinions, and values. They impact on how we learn, how we teach, how we manage, and how we are managed, and in consequence the way we organized or are organized.

The boundaries between philosophy, psychology, and sociology become almost merged when in Journey 5 we consider what it means to live in a plurality of social systems, and the demands they make on us. The focus of the journey changes to managing ourselves and others since in the future it is more likely we will have to manage ourselves. The questions self-management presents to us are philosophical in nature, starting with "who am I?"

That question cannot be answered without reference to other persons, and in the different systems that make up the communities we inhabit. Engineering knowledge is typically a community activity that is committed to "doing." The Journey 6 explores our interdependence, what it means for rights and responsibilities, and how the ideal organization be it a university or a firm is a learning community. Communities that persist have a common ethic.

The "good" in the title of Journey 7 is ambiguous. It could mean engineering a product that is good, a person who does this regularly being a "good" engineer. Or, it could mean being a good person, that is, one whose behavior is driven by moral principles. This journey explores the relationship between the two. When we think about making the good engineer possible, "What are our aspirations?"

Journey 8 finds an answer to the question "What are our aspirations?" In Bowne's aspirational ethic for engineers that is grounded in Martin Buber's view of the relationship between individuals (*I/Thou*) and McIntyre's virtue ethics. All engineers need to take an active role in considering the ethical implications of their work, and these cannot be divorced from their personal lives.

Journey 9 brings us face-to-face with technology and the impact that it is having on the structure of the workforce. Current models of the workforce seem no longer to apply. At the same time, the banking collapse of 2008 has raised questions about existing economic models and the nature of the firm—"What constitutes a company?" more profoundly "what constitutes

the common good?" Engineering students need to experience what it is to be in a community. How within all the constraints imposed on educational institutions can a collegiate climate be introduced and extended to the firm so as to enable permanent learning (continuous professional development)?

Journeys 10 and 11 seek an answer to this question. The Journey 10 begins by doubting if universities can claim to be learning systems when so few of their faculty know anything about learning or development. Theory X and Y are applied to teaching in engineering education but the central focus is on the design of the curriculum for development—cognitive and personal, and with engineering curricular that have been designed for that purpose. As the structure of higher education changes and embraces life-long learning, the findings of research on adult learning will have increasing relevance. The final paragraphs argue that teaching in engineering is a professional activity that is a discipline that has its own knowledge base.

Journey 12 is both a summary and an argument that engineering education is at a crossroads and that at the present time there are opportunities for major change.

It is three years since these journeys were given and much has happened since then. In discussions with Mani Mina and Joel Claypool, the publisher, we decided that the integrity of the seminars should be retained for which reason they have not be altered. Where it was thought new material would be valuable it has been added in a postscript to the journey, or in the notes, or both, and an additional journey has been added at the end.

John Heywood
December 2016

NOTES

[1] Whoever the individual, whatever his or her personality, they will adapt their behavior to the situation in which they find themselves. Thus, just as human organizations can be conceived of as systems, so they may also be conceived of as conglomerates of role players, for in any social system the basic unit is the role. A role is, therefore, a pattern of behavior associated with a particular position. "It carries out activities that, if the system is to achieve its goals, have to be coordinated. One activity of management is, therefore, the coordination and integration of roles. The role does not have to be a human: it could be a machine […]. Problems arise for management because a variety of individuals, each with their own value system and idiosyncracies, occupy roles in the organization. Very often personnel come into conflict with each other simply because of personality differences. Sometimes conflict is created because of the perception that individuals haven have of their role. Even in a bureaucracy it is not possible to define a role so exactly that there are no differences

in perception about how it should be performed. A major problem for employers, indeed ourselves, is the fact that at one and the same time our goals create for us a plurality of social systems. There is not merely one role system that connects the job to other jobs in the organization for work purposes, but the career system, the peer-group system and, not least the family system. All of these systems make demands on our energies and there is no way of escape. The ways we use to reduce these tensions and sometimes conflicts influence our performance at work for better or for the worse […]. Conflict and tensions are normal consequences of living systems […]. Whenever we anticipate a role, we generate expectations of what will be expected of us in that role and very often we will have to adjust those expectations […]. The need to define roles will be evident, ambiguities in roles can cause role conflict and individuals much stress." Extracts from Heywood, J. (1989). *Learning, Adaptability and Change; the Challenge for Education and Industry,* London, Paul Chapman/Sage, pp. 39–47. In recent organizational research much attention is paid to networks, the structure and management of teams, etc. xvii

[2] Trevelyan, J. (2014). *The Making of an Expert Engineer*. London. CRC Press/Taylor and Francis. xvii

[3] Youngman, M. B., Oxtoboy, R., Monk, J. D., and J. Heywood (1978). *Analysing Jobs*. Aldershot, UK, Gower Press. xvii

[4] Heywood, J. (2016). Assessment of Learning in Engineering Education. Hoboken, NJ, IEEE/Wiley. xvii

[5] Vincenti, W. G. (1993). *What Engineers Know and How they Know It. Analytical Studies from Aeronautical History*. Baltimore, The Johns Hopkins University. xviii

[6] Whitehead, A. N. (1950). *The Aims of Education*. 2nd ed. London, Benn. xviii, xix

[7] Transdisciplinary derives from the need to respond to a single complex, concrete problem that requires the assistance of several disciplines that give a variety of viewpoints to the solution of the problem which is not resolvable by a single discipline but requires the synthesis of a number of solutions. This definition has its origins in a 1973 OECD document which is summarised in (a) Heywood, J. (2005). *Engineering Education. A Review of Research and Development in Curriculum and Instruction*. Hoboken, NJ, Wiley/IEEEE. For a discussion of various models of interdisciplinarity see (b) Fogarty, R. (1993). *Integrating the Curriculum*. Pallatine, IL, IRI/Sky Publ. xviii

[8] I have translated Whitehead's major concept of creativity to fit this argument but I think he would have agreed. For Whitehead every concrete entity an individualization of the universal creative force that is his ultimate. See p. 268 of Lowe, V. (1990). *Alfred North Whitehead. The Man and his Work*, Vol. II. Baltimore, The Johns Hopkins University Press. xix

[9] Kallenberg writes "practical reasoning is the stuff of relationships both at the personal level as well as city wide (according to Aristotle) one needed to do practical reasoning well in order to live successfully each day." Kallenberg argues that "morality is identical to practical reasoning. Any act that derives from practical reasoning-whether it is telling a joke or constructing a road-is inherently moral." Kallenberg, B. J. (2013). *By Design: Ethics, Theology, and the Practice of Engineering*. Cambridge UK, James Clarke publishers. See also Book 6 of Aristotle. The Nicomachean Ethics (1996). Introduction by S. Watt. Wordsworth Classics. Ware Herts, Wordsworth editions. xix

Sternberg found among different groups of academics that their implicit theories of wisdom varied but could contribute to our understanding of wisdom. In his work on intelligence he had distinguished between academic and practical intelligence. In his balanced theory of wisdom he considers that wisdom is a special case of practical intelligence that requires the balancing of multiple and often competing interests. He said, "wisdom is defined as the application of tacit as well as explicit knowledge mediated by values towards the achievement of a common good through a balance among (a) intrapersonal, (b) interpersonal, and (c) extrapersonal interests, over the (a) short and (b) long terms, to achieve a balance among (a) adaptation to exiting environments, and (c) selection of new environments." Sternberg, R. J. (2001). Why schools should teach for wisdom. The balance theory of wisdom in educational settings *Educational Psychologist* 36, pp. 227–245. This note is based on Bassett, C. L. (2006). Laughing at gilded butterflies: Integrating wisdom, development, and learning in Hoare, C. (Ed.), *Handbook of Adult Development and Learning*. Oxford, Oxford University Press.

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Mani Mina
December 2016

As Dr. Mina has explained these journeys were undertaken in dialogue with a group of educators and doctoral students. The journeys were modified in places and the notes considerably extended as a result of these dialogues. The first of the dialogues began when Dr. Mina and John Pritchard recorded the journeys. During the course I was able to discuss what I thought was happening and where I was going with Dr. Alan Cheville of Bucknell University with whom I was already in conversation about such matters.

I am very grateful to them, to Mani in particular, and the course participants for making these journeys so meaningful.

John Heywood
December 2016

JOURNEY 1

"It all Depends on What You Mean by..."

During the 1940s and 50s, the "BEEB" (as the British Broadcasting Corporation is affectionately known in Britain), broadcast a radio show known as "The Brains Trust." During each of the 84 broadcasts that were made, a panel of four erudite personalities attempted to answer questions that were put to them. Three of them anchored the program and the fourth place was occupied by some well-known intellectual. Some of them regularly occupied this space. One of the three respondents who anchored the program began his response to any question by stating that "it all depends on what you mean by....." a particular word or phrase. He was C. E. M. Joad, a philosopher and psychologist who had written an excellent introduction to philosophy. His phrase became part of everyday language usage in the British Isles: even teenagers would be heard using it. With a laugh of course!

Many years later during an interview for a senior academic post I used the same phrase in response to an interviewer who was asking me to comment on the philosophy of R. S. Peters. Professor Peters was responsible for making the study of educational philosophy something that had to be done in university departments responsible for the education of teachers. He had said that "education was the initiation of worthwhile activity" or words to that effect [1]. Forty five or more years on it would be foolish to suggest that I can remember how the question was put, but I do know that I knew little or nothing of Peters work and that my response was to say "it all depends upon what you mean by education," etc. Of course I did not get the job!

Nowadays, I appreciate that the phrase merits some discussion. For example, it revolves around what you mean by "worthwhile activity."

I suspect that in any group of a dozen or so people while some would give similar answers others would give different answers as to what they perceived worthwhile activities to be. There would have to be some clarification, and the development of the ability to clarify is something that the activity of philosophy can encourage. But let us stay with the issue for a minute. Suppose we find that the focus of some of the answers is on worthwhile activities in the classroom while other responses refer to a range of activities from such things as gardening to going to a pop-concert, we might argue, as an observer, that only the former are educational. But who are we to say that no learning takes place in the latter? So if we change the meaning of education to learning, and if we take it that more or less everything we have to do is worthwhile, by definition we arrive at something we know to be universally true, that is, that learning takes place all the

time, contingent though it may be. Take another step and we begin to recognize that the system of formal education is a social artifact. Finally, we find that someone else is prepared to take all these arguments apart. That is what philosophers do. They take each other's arguments/systems apart, and that is how philosophy moves on but never escapes from the arguments of the past.

Joad or "Professor Joad" as he was known was being a philosopher. He showed us that many statements require clarification if their meaning is to be understood.

Read the Wikipedia biography of Joad, or any other biography that you can call up, and you will find it was Joad who popularized philosophy, that he was a socialist, that he liked the ladies, that he liked mixing with the grandees, that he wrote prolifically, that near his death bed he returned to Christianity but, you will find little or nothing about his philosophical beliefs. However, among the long list of his publications you will find "Critique of Logical Positivism." This suggests that he allowed for metaphysics in his thinking which logical-positivism does not.

One of those who joined him as the fourth panellist in the Brains Trust was the philosopher who introduced the British public to "dogmatic logical-positivism" A. J. "Freddie" Ayer. He did this through a book called *Language, Truth and Logic* which was published in 1936 [3]. Ayer was then professor of philosophy at University College London. Like Joad, he had socialist leanings although he was not a pacifist. He, too, liked the ladies to the extent that he was married four times. However, his philosophy was quite clear. Only scientific statements can be proved to be either true or false and this implies a limitation on science, and therefore philosophy, since science has to be restricted to observable aspects of nature. Metaphysical and theological statements have no meaning, and the activities of philosophy become focused on how to replace ordinary language with more precise and standardized equivalents. This is the reason for mentioning it here although as a philosophy logical positivism is no longer in the vogue that it was. Here, it is with the view that ordinary language is imprecise that we are concerned, and that is something about which most reasonable people would say of much that is spoken and written.

Wittgenstein, an engineer by education, is regarded by many as the greatest philosopher of the 20th century. In his first major study ("The Tractatus") he took a similar position to Ayer [4]. However, in later years that position was modified [5]. Nevertheless, the logical-positivists drew much support from Wittgenstein's thesis that only propositions in the natural sciences are true, moreover, it is impossible to say anything meaningful about ethics, aesthetics, and metaphysics. Thus, the clarification of meaning, which is what Wittgenstein considered to be the role of philosophy, is confined to natural science.

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, we have become 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 U.S. 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 behaviors students must demonstrate" [6]. 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 (Exhibit 1.1) were considered to be too broad to be assessed directly and in the tradition of *The Taxonomy of Educational Objectives* [7] they recommended that those aims should be broken down into smaller more measurable units. 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.

Engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering;
(b) an ability to design and conduct experiment, as well as to analyze and interpret data;
(c) an ability to design a system, component, or process to meet desired needs;
(d) an ability function in multi-disciplinary teams;
(e) an ability to identify, formulate, and solve engineering problems;
(f) an understanding of professional and ethical responsibility;
(g) an ability to communicate effectively;
(h) the broad education necessary to understand the impact of engineering solutions in a global/social context;
(i) a recognition of the need for and an ability to engage in life-long learning;
(j) a knowledge of contemporary issues; and
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Exhibit 1.1: The list of program outcomes in Section II of Engineering Criteria 2000. The Accreditation Board for Engineering and Technology (ABET).

It is easy to fall into the trap of making ambiguous statements. For example, recently I wrote in a chapter of a book a modification of a statement that I had written in a paper in 1986 [8].

It was a definition of technology in which I now substituted "engineering" for "technology." The revised statement which related to the model shown in Exhibit 1.2 reads,

> "Engineering is the art and science of making things that meet the needs of self and society. It is both an activity and a system that serves both individuals and society *that creates new problems for both*. Therefore, engineering literacy is necessarily interdisciplinary and a liberal study. Engineering literacy is about the process of engineering whereas as technological literacy is about the products of engineering and their impact on society." It was the phrase in italics that bothered the reviewer. He or she wrote- "Meaning engineering creates new problems for both? Or the fact that it serves both individuals and society creates problems?" [9] The ambiguity is immediately apparent. I was intending the former but isn't the second point valid?

In the original statement the word technology was used because those of us who wanted to include some engineering science in the middle and high school curriculum in England failed to get our idea established. Governments had begun to replace the industrial arts (woodwork and metalwork) with an approach that was based on design and make projects, and a syllabus based on a black box systems approach. Since then as members of the Technological Literacy Division of the American Society for Engineering Education have pointed out I have allowed the two literacies to become interchangeable when there are discernible differences. Some argued that I was confusing the issue so it became evident that there was a need for clarification and definition. At the same time the Division also questioned the meaning of the term technology in its title in relation to its aims. A group led by John Krupczak gave separate and different definitions of engineering and technological literacy which has caused the division to change its name so as to embrace both engineering and technological literacy. This is why summaries of their definitions are incorporated in the last sentence of the statement that has been considered [10].

Both statements were written as an introduction to the diagram which shows a model of the interrelationships between the areas of knowledge and the achievement of a technological artefact for society and the economy. First, both engineering and technology have to function within the constraints legal and otherwise, imposed by society and the environment.

The base of the model represents the person. The mind that supports the whole activity is the source of our values, beliefs and technical understanding: it is the source of our attitudes and opinions in the different social systems in which we find ourselves: it is the driver of our actions. That is how this dimension of the model has been presented on several occasions but it is also the source of our ideas and creativity. Understanding how our beliefs and values (moral and otherwise) are formed is important to our conduct as engineers and individuals but it belongs primarily to the domains of philosophy and theology which are different languages.

The three legs of the stool represent the technological aspects of engineering: research and development; data acquisition; information technology; 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

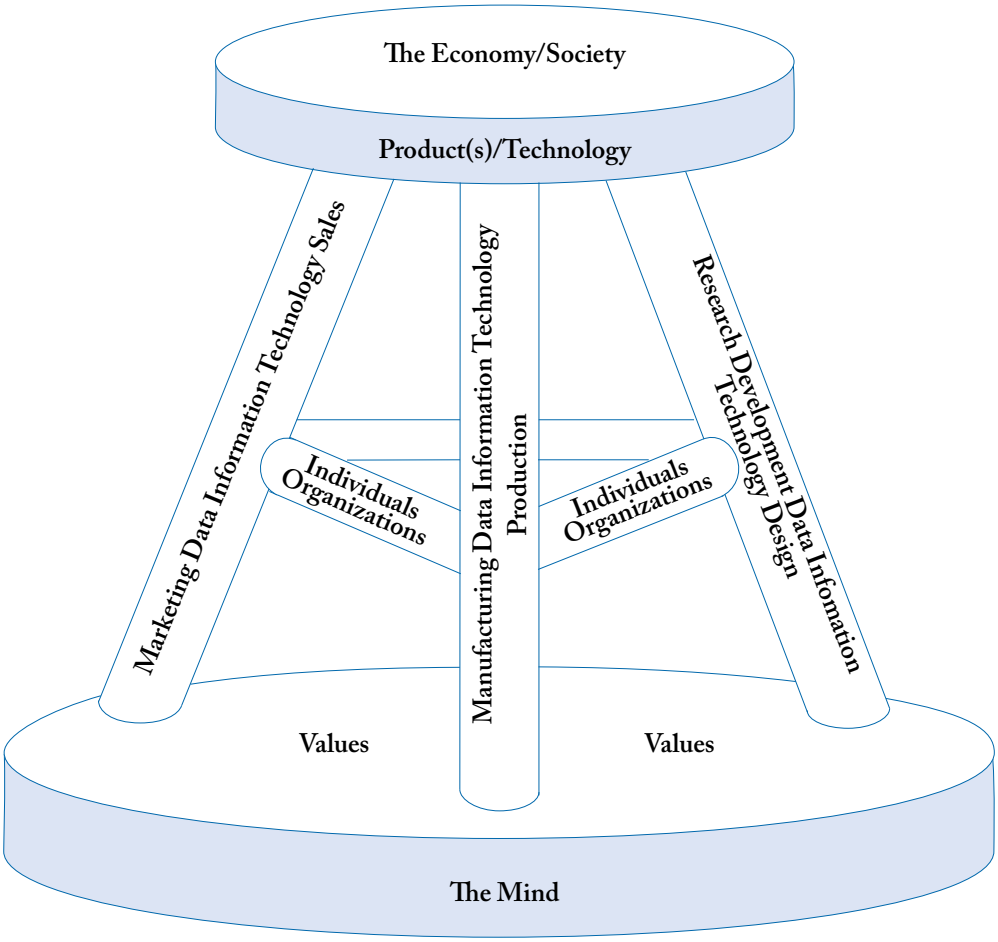

Exhibit 1.2: A model of the engineering processes engaged in the production of a technology (technological product [8]).

understanding. Supporting the legs are the trusses that represent individuals and the way the organization is structured. These are the domains of organizational behavior and behavior in organizations. The seat represents the economy and society within which the product is placed.

My purpose in introducing this limited discussion of the model is to show all the different languages that an engineer or a manager, indeed each participant has to learn if they are to understand the "meanings" that each person brings to the activity of engineering [12].

Joad's rhetoric was not idle. I make no apology for greatly simplifying the philosophical debate about logical positivism and more generally the analytic tradition in Britain because it caused the public to understand that much care should be taken to ensure that the "meanings" they

wished to convey are understood in the way they wished them to be understood [12]. Wittgenstein did not consider there was any such thing as "pure" thought. It is the language we possess that enables us to think. It is a way of life. All language is shared but that is part of another journey.

This short journey into the meaning of meaning has been taken to illustrate the kind of problem that philosophers tackle. It was inspired by a popular British philosopher's persistence in a series of radio broadcasts to query the meaning of words and statements. En-route brief excursions were made into the British analytic movement and logical positivism. No attempt was made to define philosophy. The reader was allowed to determine that philosophers consider profound questions and sometimes these lead to "isms" like American pragmatism [13]. Indeed, one way to learn philosophy is to consider its "isms." Since these "isms" are often associated with particular philosophers another way to learn philosophy is to learn about the great philosophers in historical sequence. We, in contrast, are taking a series of journeys so that we may better reflect on who and what we are as individuals and engineers within a society that is becoming increasingly complex. Our next journey is into the world of reality where we continually cross over the boundary between philosophy and psychology.

NOTES

[1] Peters, R. S. (1964). *Education as Initiation*. London, Evans. 1

[2] Joad, C. E. M. (1960). *Critique of Logical Posivitism*. London, Gollancz.

[3] Ayer, A. J. (1936 rep 2001). *Language, Truth and Logic*. Harmondsworth, Penguin. 2

[4] Wittngenstein, L. (1922). *Tractatus-Logico-Philosophicus*. Trans. G. K. Ogden. London. Routledge and Kegan Paul. 2

[5] Wittgenstein, L. (1953). *Philosophical Investigations*. Trans. G. E. M. Anscombe. Oxford, Blackwell. 2

[6] Yokomoto, C. F. and W. D. Bostwick. (1999). Modeling the process of writing measurable outcomes for Ec 2000. *Proceedings Frontiers in Education Conference 2*, 11b1, 18–22. Piscatawy, NJ, IEEE. 3

[7] Bloom, B. (Ed.). (1956). *The Taxonomy of Educational Objectives. Handbook 1 Cognitive Domain*. New York, David McKay. 3

The Taxonomy is the most widely referenced educational text of all time. Many engineering educators have used it, and it is claimed to have had a significant influence on education worldwide. It provides a hierarchical framework for categorizing educational objectives for use in test and curriculum design. The hierarchy is made up of six domains and in the text these are accompanied by sub-categories. These are expressed in terms of the behaviors a student would demonstrate if they possessed the skill required. Thus, a student has the

"ability to produce a unique communication" is one of the categories of the domain of synthesis. The six domains are Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. It was open to much criticism (see Chapter 2 of Heywood, J. (2005). *Engineering Education. Research and Development in Curriculum and Instruction.* Hoboken, NJ, Wiley/IEEE).

The authors of the *Taxonomy* made it clear that their descriptors were of the "outcomes" of education. The influence of this approach can be seen in the ABET 2000 Ec list of outcomes, and the outcomes for the different levels of the Bologna agreement. But those authorities did not use the *Taxonomy* and they preferred as have very many other educational authorities to use the term "outcome" rather than objective.

The taxonomy was revised in 2001. The Knowledge Domain was sub-divided into four—Factual knowledge, Conceptual knowledge, Procedural knowledge and Meta-cognitive knowledge. Six cognitive process dimensions were included- Remember, Understand, Apply, Analyze, Evaluate, and Create.

Anderson, L. W. et al. (Eds.) (2001). *A Taxonomy for Learning Teaching and Assessing. A Revision of Bloom's Taxonomy of Educational Objectives*. New York, Addison Wesley Longman.

[8] Heywood, J. (1986). Toward technological literacy in Ireland: An opportunity for an inclusive approach in Heywood, J. and P. Matthews (Eds). *Technology, Society and the School Curriculum: Practice and Theory in Europe*. Manchester, Roundthorn. 3, 5

[9] Personal communication, June 2013. 4

[10] Krupzcak, J. et al. (2012) Defining engineering and technological literacy. *Proceedings Annual Conference of the American Society for Engineering Education*. 4, 7

[11] Bucciarelli has made a detailed study of language usage in design teams. He points out that each person in the team lives in his/her own object world which has its own object world language. "An engineer's will be rooted in a particular scientific paradigm which serves as a basis for conjecture, analysis, testing, and designing within that world" [10]. Among the examples that Bucciarelli gives are the differences between the languages of structural and electronics engineers. As the model indicates, a design team will have to cope with other world languages outside of those in engineering and Bucciarelli notes that at the beginning of a design the perceptions that each of the members of the team have of the design will differ, and the final design will be the result of much negotiation. In this respect Bucciarelli argue that design is a social enterprise "that at its core is a conversation spoken in a language of its own invention." Design like language is a social process.

Bucciarelli, L. L. (2003). *Engineering Philosophy*. Delft, Netherlands, Delft University Press. Chapter 2.

For a detailed examination of Bucciarelli's ideas in the context of engineering ethics, see Kallenburg, B. J. (2013). *By Design. Ethics, Theology and the Practice of Engineering*, Cambridge, UK. James Clarke.

[12] Magee, B. (2001). Writes a section in his book called Common Sense that "meanwhile (in the 1930's) in Britain a near-contemporary and lifelong friend of [Bertrand] Russell's called G. Moore had been pursuing the analysis of statements in ordinary language using neither science or technical logic as his yardstick but common sense [...] into a mode of philosophy that was eventually to displace Logical Positivism. It became known as "linguistic philosophy" or "linguistic analysis," and its criterion was the ordinary use of language. The Logical Positivists had been mistaken said the linguistic analysts in trying to force the straight jacket of scientific standards on all forms of utterance. Umpteen different sorts of spontaneous discourse go to make up human life, and each one has its own logic. Philosophical problems arise when a form of utterance appropriate to one mode of discourse is mistakenly used in the wrong context" [pp. 200–201]. Magee writes of Wittgenstein that in his later philosophy "linguistic analysis achieved its ultimate degree of refinement" [p. 202]. 5, 6

Magee, B. (2001). *The Story of Philosophy*. London, Dorling Kindersley.

[13] The term "pragmatic" is in common use. In that usage it is the judgment (justification) "of any assertion of any assertion solely by its practical bearing on human interests" [*Oxford Dictionary*]. Alternatively as a philosophy it is the "theory that a proposition is true if holding it to be so is practically successful or advantageous" [Richard Rorty in the Penguin *Dictionary Of Philosophy*, 2nd ed., 2005]. 6

The principal American pragmatist philosophers are John Dewey, William James, and Charles Sanders Pierce. Biographies of Dewey and James will be found in the Penguin *Dictionary of Philosophy* (2005) 2nd ed., London, Penguin. A short biography of Pierce who was the first of the pragmatists will be found in Collinson, D. (1987) *Fifty Major Philosophers. A Reference Guide*. London, Routledge. He focused on the clarification of meaning and his best known paper is called "How to make our ideas Clear" (*Popular Science Monthly*, pp. 286–302, January 1978). The relevance of pragmatism, in particular the thinking of Dewey to engineering can be found in Omidvar, I. and M. Mina (2012). Imagining an undergraduate curriculum based on the educational philosophy of John Dewey. *Proceedings Frontiers in Education Conference*, 256–257. Piscataway, NJ, IEEE. Dewey, following Pierce, argued that learning was accomplished by "doing" since knowledge is an activity. He believed that when we met a problem its solution was found by a mental process that we would recognize today in a variety of problem solving paradigms including the process of design.

AN ACTIVITY BETWEEN JOURNEYS

Before the next journey please look at a tap slowly dripping water into a bowl. Write a description of what you see as you watch the water coming out of the tap and joining the water in the bowl below.

A kitchen tap dripping into a washing-up bowl is likely to be suitable, but you may choose any convenient tap and bowl or basin. The tap should be set to drip roughly once a second.

You will probably want 300 words for your description.

When you have written your description please answer the following questions.

1. I wrote my description

   (a) while I was observing the tap.

   (b) after watching the tap, staring to write about ..... minutes/hours after finishing watching the tap.

   (c) from my recollections (without making special observations for the present exercise)

   (i) of taps in general.

   (ii) with one particular tap in mind.

2. The tap and basin which I described

   (a) are specified in the description which I have written.

   (b) I did not specify. They were in fact ..... .

This exercise was devised by the late Dr. Ronald Stansfield of City University London.