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IMPLICATIONS OF PHILOSOPHY FOR ENGINEERING AND ENGINEERING TECHNOLOGY BACHELORS PROGRAMS

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Abstract

This paper raises the question: What is philosophy and then, after describing its branches and school, it extends the definitions to implications for the practice of engineering and engineering technology education. It folds the definitions against the work of engineering faculty. The latter was described as including curriculum development, teaching, mentoring/advising, research/scholarship, and engagement. Sample codes of ethics are shared for engineering technology students and professionals.

Keywords

Philosophy, engineering education, engineering technology education, technology

1. INTRODUCTION

Engineers and engineering technologists can certainly define technological problems, and then follow-through to design and implement solutions. Furthermore, engineering and engineering technology educators on both sides of the Atlantic have demonstrated that they can design and implement effective outcomes-based baccalaureate programs to prepare such professionals. Despite these successes, however, there is concern about whether our baccalaureate programs and processes are too technocratic in focus. This concern is fueled by real world observations of engineering failures, by well publicized ethical shortfalls, and by the relatively low participation rates of engineers and engineering technologists in society's leadership roles.

Over the existence of human kind, philosophy, because of its truly foundational character, has clearly enabled people to evolve a larger, more comprehensive welt-anschauung as well as encouraging reflective consideration of the appropriateness of their actions. Both of these characteristics are usually high among the aspirations the public, as well as our engineering societies, have for engineers and engineering technologists. Given this context, the authors raise the question: How might engineering and engineering technology education benefit from philosophy?

2. WHAT IS PHILOSOPHY

When people think about philosophy, often they see it as something profound, something that provides perspective, and something that usually raises more questions than it answers. Typically it is viewed as something that is general and not particular, i.e., direct. Furthermore, lay people tend not to see philosophy as being organized and systematic.

After reflection, however, philosophy can be considered as a way of thinking about everything. That is difficult to conceive of isn't it? Philosophy is about coming to terms with, in the simplest of language, who we are, how we see the world, and how it all fits together. Well, this generalization can be structured by considering philosophy to consist of at least four branches: metaphysics, Epistemology, Axiology, and Logic. The five classical branches of philosophy (Epistemology, Metaphysics, Ethics,

Logic, and Aesthetics) that have been developed and tested across time and in different domains are as applicable to engineering as any other human activity. In recognition of the diversity of our philosophic traditions, it is also useful to consider philosophy as existing in a number of schools, i.e., genres. Perhaps four of the most well acknowledged of these are the schools of Realism, Idealism, Pragmatism and Existentialism [1]. One might well consider the branches as being components, i.e., necessary features, of every philosophy. The schools could be considered as organized, more or less coherent thoughts across each branch. Figure 1 shows how this might be visualized.

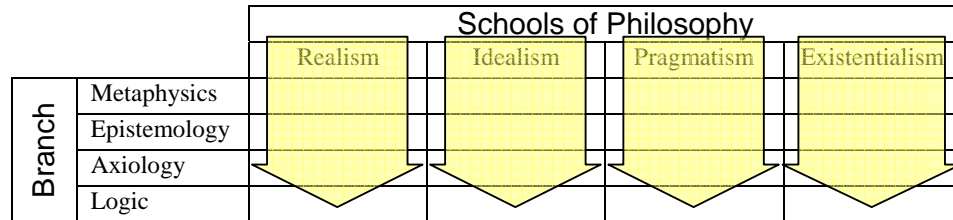


Figure 1. Philosophical schools and branches

The nature of each of the four classic branches of philosophy reveals considerable hints as to how they can apply to the work of engineering and technology faculty.

2.1 Metaphysics

This branch of philosophy deals with the nature of reality. What is real and how can we tell? Is the world one of ideas and concepts? Are all tangible items of reality some imperfect facsimile of the *real* idea? It involves ontological, mereology, and teleology considerations. Or is the reverse true. Namely that tangible objects are the only *real* things and any abstractions, concepts or ideas we derive from them are imperfect derivatives that are less real than the tangible item.

2.2 Epistemology

This fascinating branch of philosophy deals with knowledge. What is it? How do we come to know? And, how do we organize and structure it? It involves understanding the distinction between different forms of knowledge (rational, empirical etc); to consider how knowledge is acquired, recorded, maintained and used; and to provide a platform by which the provenance and limits of applicability of knowledge may be evaluated.

2.3 Axiology

The study of values is at the core of axiology. Values as applied to behavior – a subfield called *ethics* and values as applied to beauty, a subfield called *Aesthetics*. Ethics asks: What are the determinants of appropriate behaviour?

2.4 Logic

The nature of orderly thinking, i.e., reasoning is the branch labeled logic. This considers the prerequisites for effective inductive and deductive reasoning as well as other testable terms such as necessary and sufficient. It involves the concept of 'right reasoning', forms of logic (e.g., temporal logic), the role of logic in building conceptual models, and the role of logic in how knowledge is deployed.

3. PHILOSOPHY AND THE WORK OF ENGINEERING FACULTY

But, why do people even think about philosophy? Kneller [2] suggests that there are three important purposes for philosophy: (1) To speculate, (2) To presume/prescribe, and (3) To criticize/analyze. It is through such activities that engineers can convert the apparently vague generalizations of philosophy into useful, pragmatic actions.

In many ways there is remarkable consensus as to the work of faculty at universities and technology institutes. Although a variety of terms are used to describe their activities, engineering and technology faculty, around the world, are typically engaged in:

- Teaching,
- Developing curricula and learning activities,
- Research and scholarship, and
- Engagement and service.

Often the proportions of time spent on these activities vary from institution to institution, country to country or even faculty member to faculty member. But, generally the sum of time spent on these activities by the faculty of any institution would closely approximate the totality of their working hours.

Given these ubiquitous missions, and if engineering and technology faculty seek to be true to the ideal so eloquently espoused by Schön [3] in his call for reflective practitioners, it is clear that we have to consider philosophy as it applies to our daily activity. The following questions highlight some of the key questions that engineers might well consider as they engage in each category of their daily activity.

3.1 Curriculum development

- What content should I select to teach?
- Which content is most important and therefore should be emphasized?
- What content should I leave out?
- How do I best sequence/organize the content?

3.2 Teaching

- What method should I choose?
- How should I incentivize learning in my classes?
- Which problem handling method is most consistent with my teaching approach?
- What evaluation/assessment approach should I employ

3.3 Mentoring/Advising

- What is the best example I can set for my advisees?
- How do I demonstrate servant leadership?
- Would it be preferable to be a sage on the stage than a guide on the side?

3.4 Research/Scholarship

- What knowledge is of most worth seeking?
- How should I structure existing knowledge more understandably?
- What if my findings don't support my ideas?

3.5 Engagement

- How can I strengthen town-gown relationships?
- Should I try to reconcile pluralistic activities/ideas/perspectives?

- Why should I recruit?
- Is it worthwhile for me to engage with the public schools?
- Is it desirable to interact with business and industry?

4. THE IMPLICATIONS OF PHILOSOPHY'S BRANCHES FOR BACCALAUREATE ENGINEERING EDUCATION

Clearly epistemology, logic and axiology have much to contribute, while perhaps arguably, metaphysics' focus on the nature of reality may have less of an obvious impact. The authors therefore propose to highlight specific program implications of philosophy in response to targeting questions such as:

1. To speculate
2. To presume/prescribe
3. To criticize/analyze

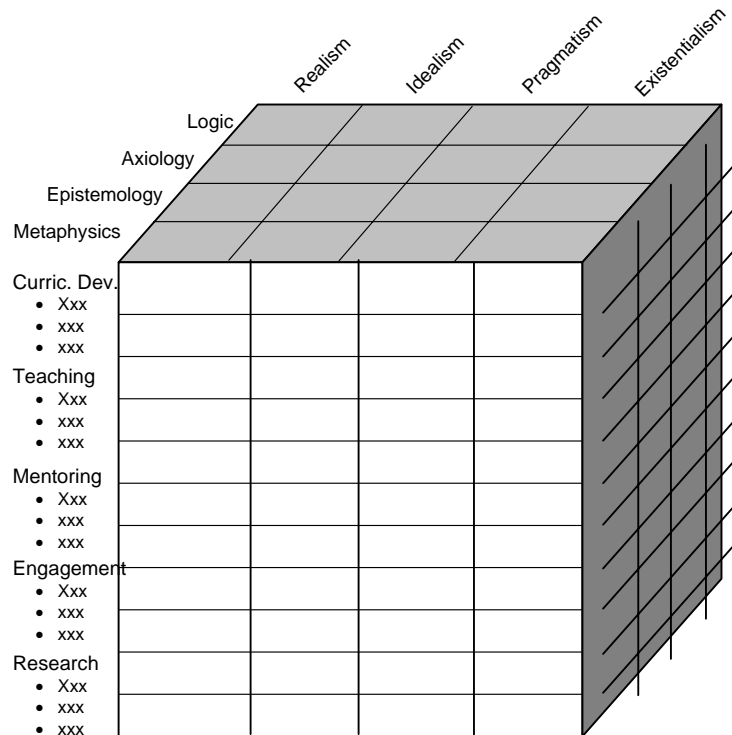


Figure 2. Matrix depicting the interaction between faculty activity and philosophy

4.1 Epistemology

This branch typically triggers analytical and critical questions and their ensuing activities. For example:

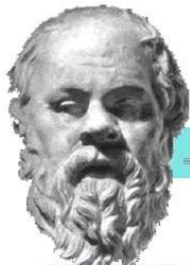
- How do engineers and engineering technologists in training/education come to know?
- How do engineers and engineering technologists in training/education organize their knowledge?

4.2 Axiology

Clearly Axiology's sub-field of ethics is the most frequently cited application of philosophy in the engineering and technology programs across the world. Naturally aesthetics also plays an important part in the aspects of our profession that deal with design. While much of our attention has been focused on making students aware of ethical codes and their implications, less time has been spent of perhaps the more seminal questions such as:

- What is the nature of ethics in engineering and engineering technology?
- What are the requirements for ethical behavior in engineering and engineering technology?

One specific way that engineering faculty might translate such questions into specific actions impacting students include promulgating codes of ethics for students (while they are in training) and for technicians/technologists (once they have graduated). Two examples generated by NJCATE (n.d.) are provided in Figures 3 and 4.



NJCATE Engineering Technicians Professional Code of Conduct

Professional engineering technicians are obligated to adhere to the following code of conduct:

Principle 1: *Hold paramount the safety, health and welfare of the public, and the protection of the environment; promote health and safety within the workplace.*

Principle 2: *Undertake responsibility for professional assignments only when qualified by training and experience.*

Principle 3: *Provide an opinion on a professional subject only when it is founded upon adequate knowledge and honest conviction.*

Principle 4: *Act with integrity towards customers and employers, maintain confidentiality, and avoid conflict of interest; where such conflict arises, fully disclose the circumstances without delay to employers or customers.*

Principle 5: *Keep informed to maintain proficiency and competence; further opportunities for the professional development of self and associates.*

Principle 6: *Be fair, courteous and act with good faith toward customers, colleagues, and others; give credit where it is due; accept, as well as give, honest and fair comment.*

Principle 7: *Present clearly to employers and customers the possible consequences if professional decisions or judgments are overruled or disregarded.*

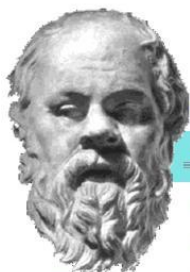
Principle 8: *Report to the appropriate agencies any hazardous, illegal, or unethical professional decisions or practices of colleagues or others.*

Principle 9: *Promote public knowledge and appreciation of their profession.*

The preceding material was adapted from the Code of Ethics and Practice Guidelines of the Applied Science Technologists and Technicians of British Columbia (ASTT). <http://rvcc2.raritanval.edu/~scieng/profcode.html>



Figure 3. Sample Professional Code of Conduct [4]
<http://rvcc2.raritanval.edu/~scieng/profcode.html>



NJCATE Engineering Technicians Student Code of Conduct

Students in Engineering Technology Degree programs are obligated to adhere to the following code of conduct:

Principle 6: *Report to appropriate college authorities any illegal, hazardous, or unethical professional decisions or practices by peers, colleagues, supervisors, instructors or others.*

Actions:

1. **Immediately report any hazardous, illegal, or unethical conduct, and take all measures required to correct or block the conduct.**
2. **Acquire, retain, and update information about the appropriate college policies for reporting such incidents.**
3. **Review and report hazards which are slow to develop (such as chemical waste disposal), with the same concern for maximum public protection given to immediate hazards.**



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Figure 4. Sample Student Code of Ethics Excerpt [4]
<http://rvcc2.raritanval.edu/~scieng/studcode.html>

4.3 Logic

Again, in logic as in axiology, our professions have focused much more on the direct awareness of the two principal forms of reasoning, i.e., deductive and inductive, than they have on such questions as:

- How does the evolution of logical thinking progress in engineering and engineering technology education?
- What are the philosophical prerequisites for effective inductive and deductive reasoning in engineering and engineering technology education?

In addition to suggesting some provocative possibilities for the redesign of engineering and engineering education programs and courses based on possibilities raised in response to the above questions, the authors will link these ideas to the processes of metacognition and knowledge management that are of critical importance to tomorrow's successful engineering and engineering technologists.

4.4 Curriculum development

- What should be the goals for our engineering and technology programs?
- What should be included in the course?
- What content is most important?
- What are the epistemological guidelines for structuring content, i.e., taxonomy?

Faculty need to consider how to change some of the goals of engineering and engineering technology programs of the future. Recently Badley [5] articulated:

Indeed, the *crisis in culture* is our uncritical adoption of a mechanistic – scientific – technological – world view (see Biesta & Burbules, 2003, p. 13) [6]. This crisis in culture is also a crisis in rationality since scientific rationality is thought to be confined to *hard facts* and *means* while *human values* and *ends* appear to be excluded from rational (i.e., scientific) deliberation (Biesta & Burbules, 2003, p. 13). ... The solution is an *integration* of the beliefs we have about the world and the values and purposes that should direct our conduct (p. 487-488).

Grimson, Dyrenfurth & Murphy [7] in a chapter prepared for a new book entitled *The Challenges in Engineering & Society*, highlighted additional implications of philosophy for curriculum development in the following two quoted paragraphs:

Badley [5] worries that "our current cultural consensus is too dominated by a form of *competitive globalization*...(2003, p. 478)," and claims that two ideologies *science-technology* and *business-economics* dominate "our post modern world culture (p. 487)." ... Despite compelling arguments such as those raised by the USA Council on Competitiveness [8], pragmatists "resist the attempt of the new economy to consume our valued educational institutions. They do so on the grounds that institutions such as universities have always had and should continue to have broad cultural, humanistic, and social objectives which should not be overwhelmed or crushed by globalization, commercialization and marketization (p. 489)." Given this, and working from the pragmatic perspective of contemporary culture, Badley claims that effective education must serve integrative purposes that "bind culture and education together (p. 477)."

The situation has not been helped by the engineering science movement which has led to a gradual de-contextualising of engineering programmes. Johnston, Lee and McGregor [9] express their "concern that the discourse of engineering education has been dominated by the discourse of engineering science, to the virtual exclusion of other discourses which contribute importantly to the practice of engineering." Already in 1994, Herbert Simon [10] wrote that "schools of engineering have become schools of mathematics and physics" in which, it must be admitted, dialogue and negotiation

with the public is not a central objective. Even earlier, and making a more general point, George Bugliarello [11], former Chancellor of Brooklyn Polytechnic University noted that C.P. Snow's two cultures are in fact on diverging trajectories. In part this might be due to difficulties with the language of discourse. Wittgenstein [12] pointed out in his posthumously published *Philosophical Investigations* that although we may believe we are speaking a common language with our fellow colleagues, it is very often the case that what we understand from our own perspectives is quite different for each. An economist or historian may understand things quite differently to their colleagues in civil engineering or environmental science. In Wittgenstein's terms, we are involved in different 'language games' and we must learn the rules of the different games if we are to communicate meaningfully.

4.5 Teaching

- Perhaps we should teach only that which is most difficult to learn on one's own?
- How do I engender learning best – constructivism vs. instructionalism?
- How can I enhance the leadership capabilities and inclinations of our graduates?
- How can I help my students become aware of and understand divergent perspectives?

With respect to teaching, the authors, in their recent book chapter also highlighted the implications of philosophy for engineers considering their teaching:

But a more specific case can be made along the lines that engineers need to be well equipped if they are to be leaders in their community and capable of entering into meaningful dialogue (discourse) with their fellow citizens. Engineers contributing to or even initiating a debate with those who express and hold an anti-technology stance need to understand the 'language' of all participants: and it is not reasonable to expect that others adapt to the language and mind-set of the engineer. This need to counter or at least understand the anti-technology stance is often associated with the postmodern movement and that is discussed in Samuel Florman's [13] book *The Existential Pleasures of Engineering*. As an aside, that book was first published in 1976 and was re-printed in 1994, and its main topic and themes are as relevant today as they were over a quarter of a century ago - pointing to at least a partial failure of the profession to heed its message. Engineering as political judgement has been considered by many authors and Little, Barney and Hink [14] in a general review of professional ethics make the point that "the call to engineers to engage in their practice politically echoes the obligation to attend to the public welfare that is explicitly stated in most of the ethical codes that govern the contemporary profession." Taft Broome [15] arguing for a 'unity principle' applicable to engineering notes that generalist expertise, being different to specialist expertise, "consists in the ability to obtain meanings of a broad variety of learned works from their storied terms, and in the skill to bring them to bear upon the problems of participating effectively in public decision making venues, and finding and fulfilling one's destiny in globalizing cultures." This phrase *participating effectively in public decision making venues* echoes a point made by Florman and succinctly states the challenge that the profession should be obliged to address.

4.6 Mentoring/Advising

- What do I do to instill ethical behavior?
- How can I promote inclusiveness and a valuing of diversity?

Faculty, through their mentoring/advising activities, need to help students understand the needs of society and meeting those needs in a technologically sound and sustainable manner, whilst keeping within the constraints set by the citizen stakeholders, is a fundamental goal for engineers. To set and reach these goals requires leadership. Since engineering has been and continues to be at the forefront in shaping our modern world, such leadership should come not just from within society in general but also from within the engineering profession. .

4.7 Research/Scholarship

- Why should I engage in research/scholarship?
- Does all this research ever add up to anything anyway?
- If we didn't think it up how can it be important?

Faculty need to ask the right questions as they frame their research and scholarship activity. This was pointed out by Badley [5] who noted:

Indeed, the *crisis in culture* is our uncritical adoption of a mechanistic – scientific – technological – world view (see Biesta & Burbules, 2003, p. 13) [6]. This crisis in culture is also a crisis in rationality since scientific rationality is thought to be confined to *hard facts* and *means* while *human values* and *ends* appear to be excluded from rational (i.e., scientific) deliberation (Biesta & Burbules, 2003, p. 13) [6]. ... The solution is an *integration* of the beliefs we have about the world and the values and purposes that should direct our conduct (p. 487-488).

4.8 Engagement

- Seeing as industry and business sees things so differently than how we professors do, why should I interact with them?
- Why does the university not value engagement as much as I think they should?

5. SUMMARY & CONCLUSION

This presentation's core thesis is that engineering and technology education necessarily must involve active consideration of philosophy if our profession is to be responsible to its ideals and society's hopes. Then to help make philosophy more tangible the authors shared a structure of the branches and schools that comprise philosophy. Importantly, key questions engendered by each of these aspects of philosophy were also shared to stimulate professional action in this vein. The authors' hope is thereby to encourage philosophical thinking and influence by and on the profession.

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