

# Philosophy of Technology in Engineering Education

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**Abstract** - In reflecting on the philosophy of engineering education as a distinct field, questions from other fields of philosophy are encountered. Among these, in addition to philosophy of education, are: ethics, epistemology, ontology, philosophy of science, and philosophy of technology. Within the philosophy of technology, a discussion of “philosophy of engineering” has been pursued in recent years. In this paper, the areas described and questions raised by philosophy of technology, specifically philosophy of engineering will be briefly presented.

The importance of philosophy of technology for the philosophy of engineering education will be developed. In *Teaching About Technology* (2005), Marc J. de Vries identified four reasons for engineering educators to become acquainted with philosophy of technology. The reasons are: (1) philosophy of technology can yield insights into curriculum development, (2) it can provide a conceptual basis for understanding technology, (3) it helps position the teaching of engineering among other subjects, and (4) it is helpful in identifying the research agenda in engineering education. Included in this paper will be a discussion of the literature in the discipline of philosophy of technology [1].

*Index Terms* – Philosophy of Engineering, Philosophy of Engineering Education, Philosophy of Technology

## INTRODUCTION

For some of us interested in philosophy of engineering education, the philosophical pursuit can be described as a meta-, or second-order endeavor. The endeavor is not primarily to create “a philosophy of engineering education,” as in statements such as “the philosophy of education in the Engineering College at XYZ University is ....”

In fact, philosophy of engineering education cannot be “a” or “the” philosophy of engineering education, except as it describes a set of questions or areas of concern. Philosophy of engineering education has as its purpose the examination of the assumptions of each “philosophy of engineering education” or of each more general worldview upon which “a” philosophy of engineering or “a” philosophy of education is built. Philosophy of engineering education as an endeavor includes a critical evaluation of the language, intentions, and implications of foundations of engineering, education, and engineering education.

Philosophy of education is a well-established discipline in philosophy with a long history. Clearly its methods, tools, and subjects are also relevant to philosophy of engineering education.

Philosophy of engineering (as understood here in a meta- sense), however, is a relatively new pursuit. In the philosophical literature, it has been subsumed under the field of philosophy of technology. This paper will provide an all-too brief survey of philosophy of technology and the questions with which it deals. It will highlight the philosophy of engineering. The ABET 3 a-k requirements will be used as a skeleton on which to view this presentation.

ABET requires that accredited engineering programs show that their graduates attain certain abilities, understandings, knowledge and recognitions. These characteristics are listed in the document *Criteria for Accrediting Engineering Programs* and are commonly referred to as “3(a-k)” [2]. Table I summarizes these requirements. For the purposes of discussion, in the table, the criteria are grouped to four categories: technical, design, interpersonal, and ethical and social. In addition, the table emphasizes that each ABET criterion involves knowledge, skills, and attitudes [3].

From the table, by criterion, let us pose the following questions:

### Technical (a & k)

1. What constitutes engineering knowledge? (The epistemological question)
2. What is science?
3. What is engineering?
4. How do we define “tool”? or What is a tool?
5. How is engineering distinguished from artisanship? Or is it?

### Design (b, c, & e)

1. What is design?
2. Is there an engineering design method?
3. Is there an experimental method?
4. If so, is there a difference between scientific and engineering experimental methods?
5. What constitutes creativity?
6. Is there a worldview associated with the engineering approach to problem solving?
7. Who categorizes risk?
8. How does the uncertainty inherent in engineering differ from scientific uncertainty?
9. Are technical problems self-evident or socially determined?

TABLE I. REORGANIZED ABET a-k CRITERIA [3]

Outcome Criteria	Knowledge	Skills	Attitudes
Technical			
a. Apply knowledge of math, science, engineering	Applied science	Comprehend technical literature	Value rigorous technical knowledge
k. Use techniques, skills & tools of engineering	Engineering tools	Efficient, effective use of tools	Need to assess limitations of tools
Design			
b. Design & conduct experiments, interpret data	Experimental method	Laboratory techniques	Empirical stance
c. Design a system, component or process	Design methodology	Design process, creativity	Open to risk and uncertainty
e. Identify, formulate & solve engineering problems	Engineering approach	Effective solution algorithms	Desire to solve technical problems
Interpersonal			
d. Function effectively on multidisciplinary teams	Team dynamics	Interpersonal communication	Valuing others opinions
g. Communicate effectively	Forms of communication	Writing, public speaking	Clarity & understanding
Ethical / Social			
f. Understand professional, ethical responsibility	Principles of ethics	Analyze situations responsibly	Personal responsibility
h. Broad education to understand social context	History & social science	Use of multiple perspectives	Social responsibility
i. Ability & desire to pursue life-long learning	Preferred learning style	Self-directed learning	Self-improvement
j. Knowledge of contemporary issues	Political & social issues	Evaluating critical issues	Objective analysis of issues

10. Are engineering and the empirical stance identical?

Interpersonal (d & g)

1. Is there an engineering “language”?
2. What is collaborative design?

Ethical and social (f, h, i, and j)

1. What is ethically required of an individual in an engineering position?
2. Are there professional codes of ethics?
3. What is the social responsibility of the engineering profession?
4. What is the social responsibility for the individual engineer?

5. What is the engineer responsible for? (Questions of sustainability, environmental ethics, etc.)
6. What is the political responsibility of the engineer, for example, as a technical expert?
7. Is self-improvement individual or social?

Many, if not all, of these questions can be seen as questions of philosophy of technology. In *Philosophy of Technology* (1988), Frederick Ferré suggests that another productive way to approach philosophies “of” is to view each under four aspects: epistemology, axiology, metaphysics, and methodology [4].

TABLE II. “PHILOSOPHIES OF” IN TERMS OF FUNDAMENTAL PHILOSOPHICAL QUESTIONS (BASED ON FERRÉ [4])

		Philosophy of :				
		Religion	Science	Technology	Engineering Education	...
Epistemology	Theories of knowledge	What is religious knowledge?	What is knowledge?	(a & k) 1	What is engineering learning?	
Axiology	Theories of value and ethics	What are the religious values?	What are the basic values of science?	All of: f, h, i, j	What values are assumed or needed in engineering education?	
Metaphysics	Theories of being or reality	Is there a God? What is the ontological status of God?	What is the ontological status of scientific entities?	(a & k) 4, (b, c, & e) 6	What is the ontological status technology or the entities associated with it (e.g., tools)?	
Methodology	Logic	What types of argument can be used in proving the existence of God?	What is the justification for the empirical method?	(b, c, & e) 1-5	Is there an engineering method? If so, what is the method and what is its justification?	

Taking this view, the questions listed in Table II can be considered questions of one of Ferré's four categories. Some of these are shown in the table. This is a small set of typical examples: the list is representative only.

Ferré's approach is only one of many that attempt to describe or define the field philosophy of technology. Each of the works listed in the *Selected Bibliography*, especially in the section *Introductions and Textbooks*, provides some discussion of the description of philosophy of technology. One such attempt that aims at inclusiveness rather than delimiting the field is given by Kaplan:

Philosophy of technology is a critical, reflective examination of the nature of technology as well as the effects and transformation of technologies in human knowledge, activities, societies, and environments. The aim of philosophy of technology is to understand, evaluate, and criticize the ways in which technologies reflect as well as change human life individually, socially, and politically [5].

In the publication of the Society for the Philosophy of Technology, a recent analysis of the current state of philosophy of technology is given by Durbin [6]. Durbin provides a chapter on the philosophy of engineering. Mention will be made in this paper of several connections between ethics and philosophy of technology and philosophy of engineering education. Epistemology, metaphysics, and methodology will be the areas discussed more in this paper. This is not intended to minimize the importance of ethics, but it is felt that ethical questions are covered extensively in other papers, especially in the sessions on ethics.

## BRIEF HISTORICAL BACKGROUND

### Philosophy of Technology

Carl Mitcham provides an older, but accessible, introduction to the history of the field in "Philosophy of Technology" (1980) [7]. As he notes, some philosophers would trace the beginnings of philosophy of technology back to any discussion of human "making" by acknowledged philosophers, such as Aristotle, for instance in *Metaphysics* and *Nicomachean Ethics* [8]. Taking a shorter focus, one can date the beginning of philosophy of technology with the first use of the phrase by Ernst Kapp as the title of his work *Grundlinien der Technik* in 1877. "Modern" philosophy of technology can be viewed as beginning with the works of Lewis Mumford, *Technics and Civilization*, and José Ortega y Gasset, "Thoughts on Technology," in the 1930's [9]. An important critique of technology that has had lasting influence on philosophy of technology was published in 1949: Martin Heidegger, "The Question Concerning Technology" [10]. In line with the temper of this work and Mumford's later work, much of the literature in philosophy of technology is very critical of technology.

For a recent analysis of the current state of philosophy of technology see: Paul Durbin, *Philosophy of Technology*:

*In Search of Discourse Synthesis* [6], which can be found on-line at the Society for Philosophy and Technology web site. (See Bibliography.)

### Philosophy of Engineering

Much of contemporary philosophy of technology deals with issues that are in fact issues for engineers. Friedrich Dessauer was a German engineer and an early writer on philosophy of technology. As pointed out by Mitcham, Dessauer believed that the three Kantian critiques (*Critique of Pure Reason* (1781), *Critique of Practical Reason* (1788), and *Critique of Judgment* (1790)) should be supplemented by a *Critique of (Technological) Making*. Dessauer saw "making", or inventing, as the resolution of several of Kant's metaphysical dilemmas.

Another approach to the epistemological questions has been described by Steven L. Goldman:

Engineering problem solving employs a contingency based form of reasoning that stands in sharp contrast to the necessity based model of rationality that has dominated Western philosophy since Plato and that underlies modern science. The concept 'necessity' is cognate with the concepts 'certainty', 'universality', 'abstractness', 'theory'. Engineering by contrast is characterized by willfulness, particularity, probability, concreteness and practice. The identification of rationality with necessity has impoverished our ability to apply reason effectively to action. [... locate] the contingency based reasoning of engineering in a philosophical tradition extending from pre-Socratic philosophers to American pragmatism, and suggests how a contingency based philosophy of engineering might enable more effective technological action [11].

### Issues in Philosophy of Engineering

- What is engineering?
- Investigations of engineering language and basic concepts
- Analysis of the structure and dynamics of engineering theories
- Development of a meta-theory and methodology of engineering judgment and engineering decision-making
- Problems in the philosophy of mind in engineering

As a comparison, in "Philosophy of Medicine," H. Tristram Engelhardt, analyzes the field in three areas of traditional philosophy: epistemology, philosophy of mind, and ethics [12]. The parallels between engineering and medicine, when both are viewed as examples of professional practice, can be useful in framing questions that might be seen as questions of relevant to the philosophies of education for each.

**PHILOSOPHY OF TECHNOLOGY FOR PHILOSOPHY OF ENGINEERING EDUCATION**

The answers offered to the questions posed by philosophy of engineering and philosophy of technology, with respect to the questions posed in the philosophy of engineering education, have been stated by Marc J. de Vries. In *Teaching About Technology* (2005), he points out the answers to these philosophical questions have direct connection with questions of curriculum development, the conceptual basis for understanding engineering, situating the teaching of engineering among other subjects, and identifying the research agenda in engineering education.

**Curriculum Development**

For curriculum development, questions in philosophy of technology and engineering about control of technology and responsibility for technology are important. For example, the answer to the question: Is technology autonomous or is it “controlled”? directly impacts the content and structure of technical curricula.

Another concern for curriculum development is technological literacy. Another way of looking at this is stated by the NAE in *Educating the Engineer of 2020*:

The engineering education establishment must also adopt a broader view of the value of an engineering education to include providing a ‘liberal’ engineering education to those students who wish to use it as springboard for other career pursuits, such as business, medicine, and law [13].

This would require the re-conceptualization of undergraduate engineering as “pre-engineering,” such as in medical practice.

**The Conceptual Basis for Understanding Engineering**

Philosophy of engineering specifically asks the question “What is engineering?” The various answers to this question have clear implications for engineering education. Viewing engineering as essentially design, or problem-solving, or applied science impacts educational methods. A methodology of engineering that is different from a methodology of science or a methodology of management or a technician’s method, again, has direct educational implications.

**Situating the Teaching of Engineering among Other Subjects**

As shown by the philosophical connections in Table I and Table II, there are many non-engineering subjects required in engineering education. In addition to the sciences there is the broad education needed to understand social context as well as knowledge of contemporary issues. In addition, there is an emphasis in engineering education on leadership and entrepreneurship. For example, from *The Engineer of 2020*:

We aspire to an engineering profession that will rapidly embrace the potentialities offered by creativity, invention,

and cross-disciplinary fertilization to create and accommodate new fields of endeavor, including those that require openness to interdisciplinary efforts with nonengineering disciplines such as science, social science, and business....

By 2020 we aspire to engineers who will assume leadership positions from which they can serve as positive influences in the making of public policy and in the administration of government and industry [14].

The corollary of this is equally true: engineering educators are concerned with situating the teaching of other subjects along with engineering.

**Identifying the Research Agenda in Engineering Education**

A rigorous research agenda in engineering education is rapidly taking form. In January 2005, *The Journal of Engineering Education* [15] devoted the entire issue to the “state of the art” in engineering education. De Vries lists the following research questions that bridge philosophy of technology and engineering education:

- How do students perceive technological artifacts? Do they recognize their functional nature?
- Do students realize that technological knowledge has an inherent normative component? Are they aware of the knowing-that and knowing-how types of technological knowledge?
- Do students have a clear view of what are essential components of a design process?
- Do students recognize both the positive and negative possible impacts of technology? Are they aware of the non-neutral character of technology or do they have an instrumental view of it?
- Is there a difference between the experts’ perception of technology and the students’ perception?
- Are educational situations set up to influence the students’ concept of technology? Do these educational situations influence students’ conceptions so that they become closer the experts’ opinions? [16]

On a more mundane level, philosophy of technology can contribute insight into questions of the use technology in education. Questions about artificial intelligence and man-machine interfaces, as well as technology as extensions of human organs, have been discussed in the philosophy of technology literature.

**Ethics in the Philosophy of Engineering Education**

There is a large body of literature on engineering ethics. This literature ranges from meta-ethical monographs to textbooks and case studies on engineering ethics. As mentioned, previously, ethical aspects of philosophy of technology will not be treated in any depth in this paper. However, a few comments are in order.

The ethical issues in engineering can be clarified by philosophy of technology in directly as ethics has been a key aspect of philosophy of technology since its inception. It is recognized both by the ABET criteria and engineering

society Codes of Professional Ethics that ethical responsibility is required.

Some specific ethical concerns of interest to engineers to which philosophy of technology contributes some insight are: safety, environmental issues, privacy, risk analysis, and military use of technology [17].

### CONCLUSION

The field of philosophy of technology, especially the philosophy of engineering, raises questions in epistemology, metaphysics, ethics, and methodology. Some of these questions and their relation to the philosophy of engineering education have been pointed out in this paper. The connection between ABET 3(a-k) and philosophy of technology has been drawn. While this has been a cursory introduction to philosophy of technology, it is hoped that its relevance for the discipline of engineering education and philosophy of engineering education is acknowledged.

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For those wishing to investigate these questions in more depth, the following works in philosophy of technology should be readily available in print or in most libraries. Several of the works listed have extensive bibliographies. Specifically on the philosophy of technology for engineering education, the work by de Vries contains an annotated bibliography. In addition, a longer version of list is provided on the Philosophy of Engineering Education website: <http://www.ws.binghamton.edu/PhilEngEd/>.

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