

Engineering Ethics and Sustainability

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Abstract

Engineering ethics and sustainability are important components of engineering education and professional practice. Both are included in the International Engineering Agreements Graduate Attributes and Competencies that are the basis for accreditation under the Washington Accord. The purpose of this paper is to review where we are in infusing sustainability ethics into engineering education focusing on Washington Accord signatory countries and to briefly describe an expanded U.S. National Academy of Engineering Online Ethics Center that should be a valuable resource for programs infusing ethics and sustainability into engineering curricula.

KEYWORDS: *accreditation, ethics, sustainability*

1. Introduction

The purpose of this paper is to review ethics and sustainability in engineering education from a top down global to local perspective. The focus is on the World Federation of Engineering Organizations (WFEO) and the International Engineering Alliance (IEA). The IEA and WFEO recently

signed a MOU and are currently developing an agreement to work together on engineering accreditation.[1] Accreditation sets the standard for what engineering graduates should know and be able to apply. The U.S. National Academy of Engineering (NAE) is expanding its Online Ethics Center (OEC) and with increased global coverage should be a valuable resource for teaching and learning the ethics of sustainability in engineering practice. Codes of ethics have been important drivers of sustainability and sustainable development in engineering and the ethical aspects of sustainability and sustainable development are receiving increasing attention by academics and practitioners.

2. Knowledge Expectation

Ethics and sustainability are prominent in the UNESCO report on Engineering; see for example articles by Bugliarello, Ridley, Didier and others.[2] Byrne et al reviewed sustainability expectations for engineering graduates in the context of codes of ethics for most of the Washington Accord signatories.[3] This paper builds on the most recent Byrne paper.[4]

2.1 WFEO ethics and sustainability

Sustainability is explicitly included in the WFEO Model Code of Ethics under Canon 4 protection of the natural and built environment.[5] The WFEO Model Code of Practice for Sustainable Development and Environmental Stewardship provides a comprehensive approach to sustainability in engineering practice.[6] The WFEO is working with the IEA to develop a MOA to work together to mentor countries wanting to join the IEA.

2.2 IEA Ethics and Sustainability

The IEA Graduate Attributes and Competences are the foundation for accreditation of engineering programs under the Washington Accord (WA). To be recognized under the Washington Accord the accreditation process must ensure that the attributes of graduates of a signatory's programs are substantially equivalent to the IEA graduate attribute exemplars. Graduates are expected to be able to demonstrate both knowledge and competencies.

WK7: Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability

According to the IEA Glossary of Terms, comprehension is synonymous with understanding.[7] The American Society of Civil Engineers Body of Knowledge (2nd edition) uses Bloom's taxonomy with comprehension being level 2 and application level 3.[8]

Engineering graduates from all programs accredited under the IEA Washington Accord can be expected to have an understanding of both ethics and sustainability in the context of engineering practice in their field.

Table A1 summarizes some of the phrases in accreditation criteria that reflect this requirement. Most of the statements use understanding for comprehension.

At the Professional Level, practicing engineers are expected to:

WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts. (WK7)

This is a level 4 or 5 Bloom outcome building on the knowledge base from formal education. The key word here is complex; an appreciation of complexity will only be acquired with practice. Evaluate is reserved for level 6 in the ASCE BOK2. At the professional level we have

WA8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. (WK7)

This attribute can be interpreted as level three. The new program criteria for ABET accredited civil engineering programs requires level three for both sustainability and ethics; graduates must be prepared to include principles of sustainability in design and to analyze issues in professional ethics.[9] However, program criteria are curriculum requirements not outcomes so the content must be in a program but there is no expected assessment of student understanding or comprehension.

At this point, the expectation for most WA engineering graduates is level 2 - comprehension - but there may be other requirements for specific fields similar to the ASCE program requirements.

3. Educational Approaches

In this paper we are particularly interested in how ethics and sustainability are being integrated in engineering education. Kibert and coauthors do this

in a book that could be used as a textbook or reference for practitioners.[10] It could also be a text for a full course in sustainability ethics.

Both sustainability and ethics could be included as modules in courses throughout a program from an introductory course to a culminating design courses and there are many examples of this being done. Mulling et al described their experience with a sustainable design project in a first year course. Reported student feedback indicated that ethics and sustainable design were effectively combined.[11] Dawash et Al describe their efforts to integrate sustainability and environmental ethics in a construction engineering program.[12] Robinson and Sutterer describe their approach to integrating sustainability into a civil engineering program.[13] They start with a discussion of sustainable development in the ASCE Code of Ethics in an introduction to civil engineering course. Veeraghanta and Frost describe their experience integrating sustainability and ethics in a first year course at the University of Utah.[14]

There is no shortage of resources for teaching sustainability and ethics. Engineering ethics case histories developed by the UK CETL are available on their web site and include sustainable development.[15] The CETL case study on sustainability ethics deals with heritage sites and is on a Leeds University site.[16] Ashley discusses the role of the civil engineer in: engineering ethics and major projects in the context of the sustainability challenge from Prince Charles.[17] The ICE has an Ethics Toolkit for practitioners and academics.[18]

In Australia, engineering ethics and sustainable development have been addressed in engineering education for more than 20 years, see for example the 1995 paper by Beder.[19]

The work of Byrne and his colleagues in Ireland has already been mentioned. Byrne describes his experience at University College Cork with ethics and sustainability in a first year introductory module in chemical engineering.[20]

Reid in a doctoral thesis provides a comprehensive review of the evolution of ethics and sustainability engineering education in New Zealand engineering education as background for designing an undergraduate module at the University of Auckland.[21]

Masud et Al discuss generally what is needed to introduce sustainability into engineering education in Malaysia.[22]

The challenge may not be so much resources but how to teach ethics and to a lesser extent sustainability. Ethics and to some extent sustainability require that instructors not rely exclusively on lectures - still the predominant mode of instruction in engineering.

4. The U.S. National Academy of Engineering Online Ethics Center

The NAE Online Ethics Center recently (2014) began an expansion project funded by the U.S. National Science Foundation (NSF) to become to the “go to” place for engineering ethics.[23] The coverage goes beyond engineering ethics but engineering ethics is already a strong component of the OEC and this component will be strengthened particular the international coverage with the expansion.

The University of Delaware's Center for Science, Ethics and Public Policy (CSEPP) is leading the international component of the expansion. The goal is to incorporate a more comprehensive international component in the center resources. This effort is seeking to identify a cohort of international collaborators to contribute to the center.[24]

During fall 2014, the OEC surveyed faculty to determine what is most important in teaching ethics to science and engineering students.[25] There was a strong response from engineering faculty including members of the American Society for Engineering Education (ASEE) Engineering Ethics Division. The Engineering Ethics Division is one of the largest Divisions in ASEE with over 1100 members. For faculty members that have taught ethics and those that have not, the most important resource for teaching ethics is case histories. A number of the case histories on the OEC are detailed including instructor notes and can be described as off the shelf and ready to use. More are needed and there are relatively few that deal with sustainability.

5. Summary

Sustainability and sustainable development are prominent in the WFEO Model Code of Ethics and the codes of ethics of many of the IEA members. Graduates of programs recognized under the Washington Accord are expected to have at least an understanding of professional ethics and sustainability in the context of engineering practice in their field. Although

there is no lack of resources for teaching and learning sustainability ethics, these resources, with some exceptions, are not easily accessible for faculty needing a module for a particular course or topics. The U.S. National Academy Online Ethics Center aspires to be the go to place for engineering ethics and if successful should greatly improve accessibility and usability. The WFEO Committee on Education in Engineering could help by assisting the OEC in reaching out broadly to WFEO members to share resources on teaching and learning sustainability ethics and to solicit a broad range of case histories that illustrate engineering practice globally.

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