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A Systematic Approach to Engineering Ethics Education

Jessica Li · Shengli Fu

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Abstract Engineering ethics education is a complex field characterized by dynamic topics and diverse students, which results in significant challenges for engineering ethics educators. The purpose of this paper is to introduce a systematic approach to determine what to teach and how to teach in an ethics curriculum. This is a topic that has not been adequately addressed in the engineering ethics literature. This systematic approach provides a method to: (1) develop a context-specific engineering ethics curriculum using the Delphi technique, a process-driven research method; and (2) identify appropriate delivery strategies and instructional strategies using an instructional design model. This approach considers the context-specific needs of different engineering disciplines in ethics education and leverages the collaboration of engineering professors, practicing engineers, engineering graduate students, ethics scholars, and instructional design experts. The proposed approach is most suitable for a department, a discipline/field or a professional society. The approach helps to enhance learning outcomes and to facilitate ethics education curriculum development as part of the regular engineering curriculum.

Keywords Engineering ethics · Ethics education · Systematic approach · Engineering education · Collaborative · Instructional design

J. Li (✉)
Department of Learning Technologies, University of North Texas, UNT Discovery Park,
3940 North Elm Street, G150, Denton, Tx 76207, USA
e-mail: Jessica.Li@unt.edu

S. Fu
Department of Electrical Engineering, University of North Texas, UNT Discovery Park,
3940 North Elm Street, B233, Denton, Tx 76207, USA
e-mail: Shengli.Fu@unt.edu

Introduction

Ethics issues in engineering have increasingly drawn attention in the past decade and have resulted in a field of research and teaching in what is called engineering ethics (Herkert 2005). The field of engineering ethics has made significant progress over the past decade. A variety of strategies and methods of teaching engineering ethics have been researched and experimented (e.g. Herkert et al. 2009; Hollander and Arenberg 2009; Haws 2006; Huff and Frey 2005). In spite of these important advances, a critical gap still exists in what to teach and how to teach engineering ethics in order to produce the best possible ethical engineers in today's fast-changing environment.

The purpose of this paper is to propose a systematic approach that aims to improve student learning from a pedagogical perspective. This proposed approach calls for an integration of ethics education with existing engineering curricula and suggests an ethics education curriculum to be taught by engineering professors as part of engineering core courses.

Curriculum development is often defined as the development of an organized set of learning activities to which learners are subjected so that their behavior will be modified in a desired and predetermined manner (Kropp 1973). Curriculum development as a process involves two critical steps: (1) determine what to teach—the content; and (2) determine how to teach—the delivery and instructional strategies. In the following sections, we will present the details of our proposed approach. First, we will discuss the process of determining what to teach—the body of knowledge that defines the field of engineering ethics and ultimate learning outcomes of the engineering ethics education curriculum (Ekstrom et al. 2006).

What to Teach

Determining what to teach engineering students in terms of ethics is the critical first step. Codes of ethics can offer guidance in designing an engineering ethics education curriculum (Colby and Sullivan 2008). Professional engineering associations and societies, such as the National Society of Professional Engineers and the Institute of Electrical and Electronics Engineers, Inc., have published their own codes of ethics and offered ethics workshops for their members (NSPE 2010; IEEE 2010). Codes can offer guidance and a common understanding of a commitment to ethics that can uphold the professional image. However, codes cannot substitute either for individual capabilities in solving ethical dilemmas (Bucciarelli 2008; Martin and Schinzinger 2005) or substitute for ethics education. The engineering ethics education curriculum should focus on providing individual students with the knowledge and skills needed to face today's ethical challenges.

Scholars have presented differences of opinion when discussing engineering ethics. Martin and Schinzinger (2005) define engineering ethics as a field that: (1) consists of the responsibilities and rights of those engaged in engineering, and also their desirable ideals and personal commitments; and (2) is the study of the decisions, policies, and values that are morally desirable in engineering practice and research. At a recent high-level ethics education workshop organized by the National Academy of Engineers, Huff and Bird (as cited in Hollander and Arenberg 2009) proposed a nine-item list of required skills for ethical engineers: (1) recognizing and defining ethics issues; (2) identifying relevant stakeholders and socio-technical systems; (3) collecting relevant data about the stakeholders and systems; (4) understanding relevant stakeholder perspectives; (5) identifying value conflicts; (6) constructing viable alternative courses of action or solutions and identifying constraints; (7) assessing alternatives in terms of consequences, public defensibility, institutional barriers, etc.; (8) engaging in reasoned dialogue or negotiations; and (9) revising options, plans, or actions.

Ladd (1980) subdivided engineering ethics into micro-ethics and macro-ethics. Micro-ethics considers individuals and internal relations of the engineering profession. Macro-ethics concerns the collective social responsibility of the profession to make societal decisions about technology (Herkert 2005) or the social context in which engineers are practicing. Most of the current teaching in engineering ethics has focused on micro-ethics and presents oversimplified situations. As a result, this educational focus may neglects the social nature of engineering practice (Bucciarelli 2008; Herkert 2005; Huff and Frey 2005). The current trend, however, points to a broader focus of engineering ethics that goes beyond micro-ethical concerns, such as social responsibilities as demonstrated in the summary of the recent National Academy of Engineering Ethics Education and Scientific and Engineering Research Workshop (Hollander and Arenberg 2009).

In addition, ethics education needs to be tailored to the requirements of a specific field. For example, ethics education used in biomedical engineering does not translate directly to electrical engineering (Hollander and Arenberg 2009). Therefore, lack of field-specific topics could fail to provide students with relevant ethical knowledge and decision making skills. Cultural sensitivity is another area that should be brought to the attention of engineering ethics educators. International students have become a permanent fixture in many of the U.S. engineering graduate programs as well as cross-cultural work teams in today's engineering firms. Cultural and ethnic diversity should be addressed in all education projects (Yutrzenka 1995). Last but not least, fast-growing technologies such as wireless communication, computers, and the Internet consistently offer new challenges of an ethical nature to ethics scholars, educators, practicing engineers, and other professionals to research and resolve.

Accordingly, it is a fundamental prerequisite for students to learn about ethical implications within the context of the social, organizational, and even political environment where engineering is being practiced (Bucciarelli 2008). In order to accomplish this goal, engineering ethics should be integrated with the field of science, technology, society, (Herkert 2005) and other related fields of ethics (O'Connell and Herkert 2004). The challenge facing engineering ethics educators is that there are no clear standards to follow in the field of engineering ethics on how much to include of each ethical aspect (Davis 2006). In making the decision on the content of an ethics education curriculum, engineering ethics educators need to consider many of the aspects presented here and possibly beyond what is addressed in this article. In the following section, we propose to use a process-driven research method, the Delphi technique, to develop a context-specific ethics education curriculum because the Delphi technique seemed to best fit the curriculum development issues (Tomkinson and Engel 2008).

Determine the Content of a Context-Specific Ethics Education Curriculum

Delphi is a research technique that has been around for half a century and was first developed by Dalkey and Helmer (1963) at the Rand Corporation. It has been widely used and accepted as a method to achieve convergence of opinions concerning real-world knowledge solicited from experts within certain topical areas (Hsu and Sandford 2007). A typical Delphi study includes the use of an expert panel and two or more rounds of sequential questionnaires to collate ideas and reevaluate their original responses (Iqbal and Pipon-Young 2009) until consensus is reached.

While the Delphi technique may not have been widely used in the field of engineering ethics, it is not new to the field of engineering. For example, Reilly (1986) reported their effort using Delphi at six state 2-year technical colleges in Georgia to revise their electronic engineering technology program. The program was successfully revised and obtained ABET-required reduction of the program at a minimum of time and expense (Reilly 1986). In 2003, Osborne et al. (2003) published their research on what should be taught in a school of science based on a Delphi study of the expert community. Eskandari et al. (2007) conducted a large-scale Delphi survey of 108 faculty members across the United States as part of their NSF-funded research project to define desired characteristics and emerging topics for an undergraduate industrial engineering curriculum. They reported that their "study is useful in the development of a model for developing an IE [industrial engineering] curriculum for undergraduate programs across the globe. The findings provide a strategic outlook for the graduates of the program and benefit them to become professional leaders…" (Eskandari et al. 2007 p. 54). There are also other more recent examples of the Delphi technique being used in curriculum modification or development in subject areas of sustainable development in engineering and engineering and technology education (e.g. Rossouw et al. 2010; Tomkinson and Engel 2008). Therefore, we believe introducing Delphi to engineering ethics curriculum development is appropriate.

A typical Delphi study can be illustrated by the following diagram (Fig. 1). It includes four major activities: form the expert panel, generate an initial questionnaire (idea), develop a formal questionnaire, conduct data analysis, and repeat the last two activities until consensus is achieved. When forming the expert panel, one should consider including not only the engineering ethics experts and faculty members but also practicing engineers and students. Collecting input from engineering students and practicing engineers about ethical issues is an important

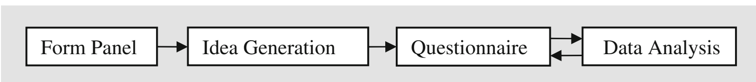

Fig. 1 Illustration of a typical Delphi process

although neglected empirical approach to the study of engineering ethics (McGinn 2003). To ensure a diverse yet balanced representation, the expert panel should include people from different cultures, ethnicity, gender, etc. The ideal group size according to Dalkey (1969) is 30 or more.

The process of idea generation may vary depending on the starting point of the curriculum development effort one is undertaking. Typically, it involves solicitation of initial ideas from the expert panel about what should be included in engineering ethics education. If a curriculum already exists, then one can use it as the starting point for the discussion. Next, the researchers will create a formal questionnaire for the panel to evaluate and to provide individual responses. The research team will analyze the inputs from the expert panel to modify the initial findings. A new questionnaire is created and sent out for the expert panel to review and give feedback individually one more time. This process may repeat a few more times until consensus emerges.

Each expert of the panel is to work individually and independently. That allows for anonymity in responses and minimizes the biases caused by dominant individuals or group pressure toward groupthink (Dalkey 1969). The examples presented earlier have supported the effectiveness of the method in achieving consensus in curriculum development in engineering fields, and the tasks can be accomplished in a reasonable amount of time (e.g. Eskandari et al. 2007; Reilly 1986). Given today's capability of online technologies, the process can be facilitated through online applications where researchers can easily access the individual panelist, survey, data collection and analysis.

How to Teach

A review of the literature reveals two issues with current teaching approaches toward engineering ethics education. First of all, there is a lack of differentiation between the delivery strategy and the instructional strategy, which may result in missed opportunities in identifying the right delivery and instructional strategies for the students given their context of study. Decisions on delivery strategy should precede decisions on instructional strategy because the delivery strategy addresses the question of how the course will be positioned in the curriculum. For example, will ethics education be positioned as a standalone course or will it be embedded in a required course, online modules, projects, or lab experiments (Herkert et al. 2009)? Instructional strategy addresses the question of what an instructor can do in the context of the teaching environment to achieve desired student learning outcomes and to provide students with the desired skills for ethical decision making. The most common or the most discussed instructional strategy is the use of case studies in ethics education (e.g. Rabins et al. 2009). However, there are many other instructional strategies, such as simulation, role play, games, and traditional strategies of lecture, group discussion, and writing assessment. It is important to consider all options and design a comprehensive instructional strategy. Focusing on one or two strategies, such as case studies, may deflect attention given to the complexity of a practicing engineer's work environment (Bucciarelli 2008).

There are a variety of approaches on how to teach engineering ethics, each with advantages and disadvantages (Bird 2003). In the following section, we will first review the current practices used to teach ethics to engineering students, and then we will discuss using an instructional design model to approach the design of the ethics educational programs.

Current Practices Used to Teach Ethics to Engineering Students

Current Delivery Strategies

1. Teaching ethics across the curriculum (also known as the "embedded approach") was presented by a number of ethics educators as a viable approach (Bird 2003; Cruz and Frey 2003; Weil 2003). This approach emphasizes teaching ethical issues in all core courses of the engineering curriculum by incorporating an ethical component or module into actual engineering courses. An advantage of this approach is that it integrates ethics into the engineering curriculum through a series of contextualized activities. Collectively, these activities should produce substantial results (Cruz and Frey 2003).

Another advantage of the ethics across the curriculum approach is its involvement of engineering professors in the teaching of engineering ethics. The professors' involvement demonstrates to students that the study of ethics is not peripheral to, or an add-on to, engineering. It is essential to engineering practice and engineering problem solving (Cruz and Frey 2003; Weil 2003). If ethics is taught by a professor from another discipline, the action may provide false information that it is not part of engineering (Zandvoort et al. 2008). Another point made by Weil (2003) is that the ethics component of courses should be designed with graded assignments, similar to other modules of the course so the student's work can be included in the final grade.

The potential weakness of this method is the process for implementation. It currently relies on engineering professors who attend a training workshop voluntarily and bring the content back to the students (Cruz and Frey, 2003; Weil 2003). When the approach was discussed, we found no mention of coordination among professors when they design and implement their ethics teaching components. This unmanaged implementation process leaves us wondering how one can be sure about the student learning outcomes. This may result in unnecessary overlap or missing important content. It is doubtful that a collective of random activities will bring the desired results to meet overall expectations.

2. A joint venture model or team-teaching model involves teaching engineering ethics as one course taught by a team of professors from a variety of disciplines (Graber and Pionke 2006; Zandvoort et al. 2008). The course may be taught by an engineering professor and a philosophy professor, for example, with all teaching activities divided 50/50. The advantage of this approach is that it provides students with the diverse expertise of an engineering professor and a philosophy professor. The involvement of an engineering professor signals the high importance of the course and raises student attention. The weakness is that this teaching model depends on the availability of a motivated and qualified engineering professor to teach the ethics subjects. K. Barald (personal communication, November 16, 2009) shared an innovative joint venture approach with us. Barald led a team that created a course uniquely for University of Michigan's large student population. They established a podcast-based lecture library that culminated from a collective effort of 53 volunteer faculty members from all over the campus. To complete an ethics course, students needed to take the requisite number of modules and attend small group discussions. This approach often requires a considerable effort in coordination and maintenance.

3. Standalone ethics courses have often been taught in engineering programs as electives and often are not taught by engineering professors. This method gives students the impression that ethics is peripheral to the engineering practice (Zandvoort et al. 2008). Some schools have made required ethics courses a part of the engineering curriculum, such as Texas A&M University. However, making it a required course may overcrowd an engineering curriculum that is already quite full (Cruz and Frey 2003). Table 1 summarizes the three key delivery methods and their characteristics on the basis of the review of the literature.

There are also other delivery strategies such as teaching ethics in the lab (e.g. Herkert et al. 2009) and teaching ethics across institutions (e.g. Virginia Polytechnic Institute and State University). The three approaches presented in Table 1 are approaches that have appeared more often in the literature. Based on our assessment of these three different approaches, we believe that the ethics across curriculum or the embedded approach is likely superior because it involves engineering professors integrating ethics into the engineering curriculum. If adding a systematically managed implementation process, this approach can potentially produce the desirable engineering ethics education outcomes consistently within and across institutions.

Table 1 Delivery models for engineering ethics and their characteristics

Type	Characteristics	Advantages	Disadvantages
Teaching ethics across the curriculum (embedded approach)	Engineering/science faculty members introduce ethics into their teaching. Ethics materials become normal components of the course	Increases the capability/confidence of faculty members to address ethics discussions in courses. Provides materials for faculty to incorporate ethics into courses	Highly dependent on faculty members' willingness. No set standards in how to integrate in teaching and how to grade
Joint venture model/team-teaching approach	One course taught by a team of professors from multiple disciplines	Diversity of input from a team of faculty members	Dependent on the availability of motivated and qualified faculty
Standalone course	One independent course taught by one professor for students to sign up individually	The content is concentrated and can cover a variety of topics in one course. Easy to manage what should be covered in the course	Not part of the engineering curriculum. May be considered as unnecessary by both students and their advisors

Current Instructional Strategies

The most discussed instructional strategy in teaching engineering ethics is the use of case studies (Fleddermann 2000). One reason case study is a popular strategy is that it provides students the opportunity to discuss, debate, construct, or try out different options. Students exchange ideas and learn from each other to form both explicit and tacit knowledge in the process (Haidt 2001; Huff and Frey 2005). In addition, cases are often written to reflect real world situations, such as the Challenger Launch Decision (Vaughan 1996) and the BART case on whistle-blowing (Anderson et al. 1980). There is not always one correct method to use a case; however, there likely will be incorrect methods to try to achieve a particular goal with a case (Huff and Frey 2005). Therefore, it is important to link a case study to instructional objectives. Each case needs to be carefully designed to help students balance critical reflections with a perspective rooted in mundane engineering practices. Understanding what may seem rational at the time can lead to normalization of deviance in organizations (Lynch and Kline 2000).

In addition to case studies, other traditional instructional strategies are used such as lectures, tutorials, written exams, team essays, and presentations (e.g. Delft University of Technology (Zandvoort et al. 2008)). These also include small group and general class discussions, group projects, readings, response papers, and exams (e.g. University of Tennessee (Graber and Pionke 2006)). Many educators have also explored other teaching methods. For example, Haws (2006) presented his approach using "the Just War" as a central theme to lead the discussions of engineering ethics throughout the course; Berne (2003) used intergenerational dialogue as a learning tool and found significant educational value in examining the ethical questions connected to the development of new technologies; Herkert et al. (2009) introduced popular news articles each week to help facilitate conversations about an important and timely topic to increase (raise) students' interest in the subject; Hirsch et al. (2003) taught ethics as a component of a project; and Kligyte et al. (2008) applied sense making to enhance learning through ethical decision making. There are a variety of instructional strategies that can be applied to teach ethics to engineering students. We believe instructional strategies should be designed to best support the learning objectives. Next, we will introduce a systematic approach to design educational modules using the instructional design model.

Determine Delivery and Instructional Strategies

The field of instructional design is associated with analyzing the needs of the learner systematically, creating various instructional solutions to meet the learner's needs and ultimately improving the learner's performance (Rothwell and Kazanas 1992). An instructional design model can be defined as a systematic process of planning instructions and using learning principles to create the conditions for effective learning (Gagne et al. 1992). Instructional design is based on the open systems theory, which is sensitive to sensors of its environment and transforms them through operations within the system, submits outputs to the environment, receives feedback, and takes corrective actions (Rothwell and Kazanas 1992). The process is carried out following a systematic process rather than carried out intuitively.

We will use an adapted Reiser and Dick (1995) model with six steps to illustrate how the systematic instructional design is accomplished (Fig. 2).

The outcomes of the Delphi technique discussed earlier provide an engineering ethics curriculum for the specific discipline and instructional goals. When writing the learning objectives, the instructional design model lays out explicitly what the learners will know and/or be able to do as a result of the instruction. The technique often suggests writing measureable learning objectives for the purpose of developing assessment tools in order to motivate learners to achieve identified learning objectives.

The next step involves examining each objective, planning instructional activities, and choosing instructional media. This step is where the instructional strategies are selected to best present the content and what type of instructional media will be used. The goal is to choose the best instructional activities and media to support the learning needs of the students. While implementing the program, feedback should be collected for the purpose of revising the instruction. Thus, when developing assessment tools, we need to measure not only students' learning outcomes but also the effectiveness of the instruction.

We recommend that the process of instructional design be a collaborative effort that involves engineering faculty and instructional design experts. Engineering faculty can provide input on how an ethics education curriculum should be delivered and when and where to integrate ethics instruction into the core engineering courses. This collaborative effort will result in a collective outcome of the ethics education curriculum that achieves overall learning objectives set by the expert panel and the engineering faculty of the discipline.

While appreciating the complexity surrounding ethics studies and ethics education, we present this approach from a pedagogical perspective in order to improve the delivery and instruction of ethics education in the field of engineering. Ethics is an integral part of the engineering curriculum and an important component of engineering problem solving (Davis 1998; Weil 2003). For a topic this important, one should consider using process-oriented approaches, such as the ones discussed in this paper, to create a context-specific ethics education curriculum and then design delivery strategies, instructional activities and media to achieve educational goals and objectives. We are confident that using this systematic approach will help produce more relevant ethics educational programs that help prepare ethical engineers who will lead the design of future technologies. We call on interested

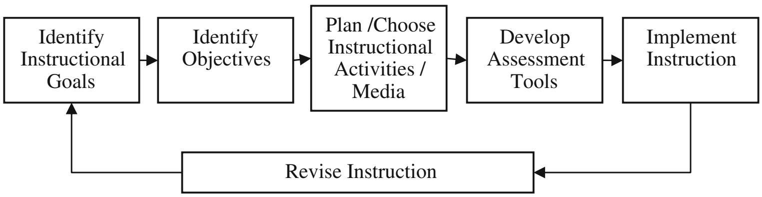

Fig. 2 Systematic instructional design model (Reiser and Dick 1995)

engineering ethics educators to join us in experimenting with these approaches and to share the findings across institutions because they can be adapted to the unique situation of the institution, especially within the same discipline. Thus, we believe that this approach is better suited for an effort of a department, a discipline/field, or a professional society.

References

Berne, R. W. (2003). Ethics technology and the future: An intergenerational experience in engineering education. *Bulletin of Science, Technology and Society, 23*(2), 88–94.

Bird, S.J. (2003). Integrating ethics education at all levels: Ethics as a core competency. Retrieved from National Academy of Engineering 29 Dec 2009 .http://www.nap.edu/catalog/11083.html.

Bucciarelli, L. L. (2008). Ethics and engineering education. *European Journal of Engineering Education, 33*(2), 141–149.

Colby, A., & Sullivan, W. M. (2008). Ethics teaching in undergraduate engineering education. *Journal of Engineering Education, 97*(3), 327–338.

Cruz, J. A., & Frey, W. J. (2003). An effective strategy for integrating ethics across the curriculum in engineering: An ABET 2000 challenge. *Science and Engineering Ethics, 9*(4), 543–568.

Dalkey, N. C. (1969). The Delphi method: An experimental study of group opinion. Santa Monica, Rand Corporation. Available from: http://www.rand.org/pubs/research_memoranda/2005/RM5888.pdf. [Accessed 25 July 2010].

Dalkey, N. C., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts. *Management Science, 9*(3), 458–467.

Davis, M. (1998). *Thinking like an Engineer: Studies in the Ethics of a Profession*. New York: Oxford University Press.

Davis, M. (2006). Engineering ethics, individuals, and organizations. *Science and Engineering Ethics, 12*(2), 223–231.

Ekstrom, J. J., Gorka, S., Kamali, R., Lawson, E., Lunt, B., Miller, J., et al. (2006). The information technology model curriculum. *Journal of Information Technology Education, 5*, 343–362.

Eskandari, H., Sala-Diakanda, S., Furterer, S., Rabelo, L., Crumton-Young, L., & Williams, K. (2007) Enhancing the undergraduate industrial engineering curriculum: Defining desired characteristics and emerging topics. *Education and Training*, *49*(1), 45–55.

Fleddermann, C. B. (2000). Engineering ethics cases for electrical and computer engineering students. *IEEE Transactions on Education, 43*(3), 284–287.

Gagne, R. M., Brigggs, L. J., & Wager, W. W. (1992). *Principles of instructional design* (4th ed.). Orlando, FL: Harcourt Brace Jovanovich, Publisher.

Graber, G. C., & Pionke, C. D. (2006). A team-taught interdisciplinary approach to engineering ethics. *Science and Engineering Ethics, 12*(3), 313–320.

Haidt, J. (2001). The emotional dog and its rational tail: A social intitionist approach to moral judgment. *Psychology Review, 108*, 814–834.

Haws, D. R. (2006). Engineering the Just War: Examination of an approach to teaching engineering ethics. *Science and Engineering Ethics, 12*(2), 365–372.

Herkert, J. (2005). Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering. *Science and Engineering Ethics, 11*(3), 373–385.

Herkert, J., Wetmore, J., Canary, H., & Ellison, K. (2009). Integrating microethics and macroethics in graduate science and engineering education: Developing instructional models, Retrieved February 6, 2010, from American Society for Engineering Education: http://soa.asee.org/paper/conference/paper-view.cfm?id=11085.

Hirsch, P. L., Bird, S. J., & D'Avila, M. (2003). Enriching the research experience for undergraduates in biomedical engineering. In *Proceedings of the 2003 American society for engineering education annual conference and exposition*. Washington, D.C, (pp 283–292) American Society for Engineering Education.

Hollander, R. & Arenberg, C. R. (2009). Ethics education and scientific and engineering research: What's been learned? What should be done? Summary of a workshop. Retrieved February 6, 2010, from National Academy of Engineering: http://www.nap.edu/catalog.php?record_id=12695.

Hsu, C., & Sandford, B. A. (2007). The Delphi Technique: Making sense of consensus. *Practical Assessment, Research & Evaluation., 12*(10), 1–8.

Huff, C. W., & Frey, W. (2005). Moral pedagogy and practical ethics. *Science and Engineering Ethics, 11*(3), 389–408.

IEEE (2010). IEEE code of ethics. Retrieved January 21, 2010, from IEEE: http://www.ieee.org/portal/pages/iportals/aboutus/ethics/code.html.

Iqbal, S., & Pipon-Young, L. (2009). The Delphi method. *The Psychologist, 22*(7), 598–601.

Kligyte, V., Marcy, R. T., Waples, E. P., Sevier, S. T., Godfrey, E. S., Mumford, M. D., et al. (2008). Application of a sensemaking approach to ethics training in the physical science and engineering. *Science and Engineering Ethics, 14*(2), 251–278.

Kropp, R. P. (1973). Curriculum development: Principles and methods. *American Journal of Agricultural Economics, 55*(4), 735–739.

Ladd, J. (1980). The quest for a code of professional ethics: an intellectual and moral confusion. In R. Chalk, M. S. Frankel, & S. B. Chafer (Eds.), *AAAS professional ethics project: professional ethics activities in the scientific and engineering societies* (pp. 154–159). Washington, D.C.: AAAS.

Lynch, W. T., & Kline, R. (2000). Engineering practices and engineering ethics. *Science Technology & Human Values, 25*(2), 195–225.

Martin, M. W., & Schinzinger, R. (2005). *Ethics in engineering* (4th edn.). New York: McGraw Hill.

McGinn, R. E. (2003). "Mind the gaps": An empirical approach to engineering ethics, 1997–2001. *Science and Engineering Ethics, 9*(4), 517–542.

NSPE (2010). NSPE Code of Ethics for Engineers. Retrieved January 21, 2010, from National Society of Professional Engineers: http://www.nspe.org/Ethics/CodeofEthics/index.html.

O'Connell, B., & Herkert, J. R. (2004). Engineering ethics and computer ethics: Twins separated at birth? *Techne: Research in Philosophy and Technology, 8*(1), 36–56.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching*, *40*(7), 692–720.

Rabins, M. J., Harris, E., Pritchard, M. S. & Lowery, L. L. (2009). Introducing ethics case studies into required undergraduate engineering course. Retrieved November, 15, 2009, from Texas A&M University: http://ethics.tamu.edu/.

Reilly, P. L. (1986). Curriculum revision using advisory committees and a modification of the Delphi technique for electronic engineering technology programs. Practicum Paper, Nova University. ED275913.

Reiser, R. A., & Dick, W. (1995). *Instructional planning: A guide for teachers* (2nd edn.). Boston: Allyn and Bacon.

Rossouw, A., Hacker M., & de Vries, M. J. (2010). Concepts and contexts in engineering and technology education: An international and interdisciplinary Delphi study. *International Journal of Technology and Design Education*. doi:10.1007/s10798-010-9129-1.

Rothwell, W. J., & Kazanas, H. C. (1992). *Mastering the instructional design process: A systematic approach*. San Francisco: Jossey-Bass Inc.

Tomkinson, B., & Engel, C. (2008). The use of a Delphi consultation to explore the curriculum for sustainable development in engineering. *International Journal of Sustainable Engineering, 1*(4), 298–303.

Vaughan, D. (1996). *The challenger lanch decision: Risky technology, culture, and deviance at NASA*. Chicago: University of Chicago Press.

Weil, V. (2003). *Ethics across the curriculum: Preparing engineering and science faculty to introduce ethics into their teaching*. Retrieved January 10, 2010, from National Academy of Engineering: http://www.nap.edu/catalog/11083.html.

Yutrzenka, B. A. (1995). Making a case for training in ethnic and cultural diversity in increasing treatment efficacy. *Journal of Consulting and Clinical Psychology, 63*(2), 197–206.

Zandvoort, H., Van Hasselt, G. J., & Bonnet, J. A. B. A. F. (2008). A joint venture model of teaching required courses in 'ethics and engineering' to engineering students. *European Journal of Engineering Education, 33*(2), 187–195.