

Board 37: Developing Globalized Petroleum Engineers (WIP)

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Roman Taraban is Professor in the Department of Psychological Sciences at Texas Tech University. He received his Ph.D. in cognitive psychology from Carnegie Mellon University. His interests are in how undergraduate students learn, and especially, in text and discourse analysis, problem-solving in engineering, and engineering education.

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Alberto Giussani, background in Petroleum Engineering, started in 1981 as a consultant on Natural Gas Hydrates and then moved to the oil and gas arena. Worked for Shell, Altura, and Oxy until December 2019. Areas of experience, water floods and CO2 floods field performance and development, hydrocarbon storage caverns, CO2 source fields. The type of work I enjoyed the most was the development and implementation of plans to either improve field performance or expand field production. Nack for working with teams/groups of different backgrounds to achieve a common goal. Since 2006, first as a part-time instructor and after 2019 as a full-time lecturer teaching in the Petroleum Engineering Department at Texas Tech, the goal of my classes both sophomore and senior levels is to prepare young minds to become strong engineers capable of working in a team concept with a deep sense of responsibility

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Work in Progress: Developing Globalized Petroleum Engineers

Abstract

Petroleum discovery, sale, and distribution have become global issues that affect communities, corporations, and governments. The challenge is to develop an understanding and appreciation in students of how oil and gas exploration differs around the globe, economically, culturally, socially, and ethically. In the present project, we have launched and have begun development of a web platform open to the world that focuses on economic, ethical, and community issues in global oil production. Development of the web platform, titled *Petroleum Engineer*, is modeled on the highly successful web platform for students' reactions to engineering ethics, the *Ethical Engineer*: <https://EthicalEngineer.ttu.edu>. The *Petroleum Engineer* website is being developed through a required undergraduate course in the PE major. The primary materials for the *Petroleum Engineer* website are petroleum engineering case studies, approximately 1000 words in length. Students read and reflect on a case study, post a comment (approximately 300 words), and post reactions to other students' comments, on a voluntary basis. Instructor-generated guidelines for students for developing comments are posted on the website to help students think critically and gain clarity on their position. Themes within students' comments will be analyzed beginning with human qualitative data analysis methods and then extended to machine-based classification methods. Students will also be surveyed regarding their web experience. The primary goal of the project is to engage students in an exchange of ideas across national boundaries, as with <https://EthicalEngineer.ttu.edu>, and to thereby aid in developing globalized petroleum engineers.

Introduction

Petroleum discovery, sale, and distribution have become global issues that affect communities, corporations, and governments. Petroleum engineering (PE) courses obligatorily teach engineering principles and practices. Increasingly, engineers must address broader issues that go beyond their technical areas of expertise. In petroleum engineering, for instance, there are economic, environmental, and ethical issues. These are viewed differently by geographic, cultural, and social groups. Petroleum engineering students are generally not aware of the diversity of beliefs and practices associated with global exploration and production of oil and gas. The challenge is to develop an understanding and appreciation in students of how oil and gas exploration differs around the globe, economically, culturally, socially, and ethically. "While there is broad agreement as to the need to better prepare engineers for global practice, there is much less agreement as to what skills and abilities define global competence, what combination and duration of international education and experiences best instill it and what means and metrics should be used to judge whether students have attained it" (p. 129) [1].

The goal of the present project is to integrate innovative technology into the petroleum engineering classroom using a global digital platform and automated assessments using machine-learning methods, in order to increase intercultural competencies in students. Current development of the web platform, titled *Petroleum Engineer*, is through a required sophomore-level course in the PE major, Introduction to Petroleum Engineering. This course generally emphasizes the relationship between geology, formation evaluation, drilling, completion,

reservoir analysis, and economic evaluation. This is the first petroleum engineering course in which students get a perspective on what petroleum engineers do. Other classes in the curriculum involve very detailed engineering principles dealing with reservoir and rock characteristic concepts. Because this is an initial course in petroleum methods, it allows introducing students to global issues involved in petroleum engineering early on. The principle behind the web resource, *Petroleum Engineer*, is to provide students with a mechanism to share their personal perspectives on economic, ethical, and social differences in their country compared to others, and to gain knowledge, understanding, and empathy towards diverse groups through these web interactions.

Through social infrastructure and values, nations risk becoming strongly ethnocentric. The *Petroleum Engineer* website may have the capability to use a digital medium to engage students in learning, discussing, and reflecting on core values and ethics in petroleum engineering, and increasing global awareness and intercultural sensitivity. There are several research questions associated with the website:

- What are workable models for intercultural faculty and student communication?
- Do students perceive benefits in sharing perspectives on a digital medium, across national boundaries, and for their development as engineers?
- How important is it, from an educational perspective, for educators and students to interact with and collaborate with peers in other countries?

The *Ethical Engineer* Website

The *Petroleum Engineer* website is being modeled on a highly successful global platform, <https://ethicalengineer.ttu.edu>, that was developed to teach engineering ethics [2, 3]. The *Ethical Engineer* website is a virtual context for ethical reflection and shared discourse. It provides an interactive platform for college students to present their comments and reactions to ethical dilemmas. That website, like *Petroleum Engineer*, arose from an undergraduate course in engineering at our institution that is required of engineering majors. Materials on <https://ethicalengineer.ttu.edu> are in English. The website and all its materials are accessible by anyone anywhere in the world. However, to post comments to the website, registration is required, and participants who post comments use a pseudonym to protect confidentiality.

The *Ethical Engineer* website demonstrates one mechanism through which instructors can reach out to establish connections outside the US around topics and issues of common interest. The website provides one possible response to the first research question that was posed, *What are workable models for intercultural faculty and student communication?* To develop and launch the website, several of the present authors worked collaboratively across several academic disciplines, including engineering, and with the institutional information technology office at our institution to connect the target class in engineering ethics to the global internet. Concurrently, we worked with international contacts to promote participation on the website through comparable courses in engineering. After mutual discussion and agreement, the website was incorporated into course curricula at partner institutions in somewhat different manners, depending on the specific course, the course objectives and content, and specific instructor. The method adopted for the *Ethical Engineer* has been quite successful. Since its inception in 2017, the website has been viewed by individuals from at least 50 different countries, and the website

has accumulated nearly 3000 registered participants, with a large proportion of registered members from non-US countries.

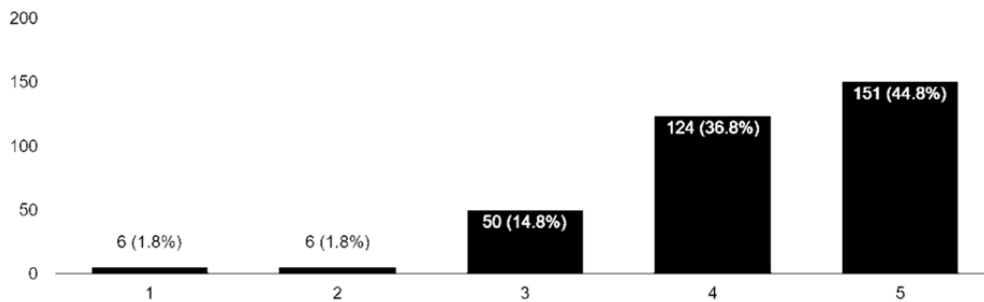
Assessment of the Web Resource

The *Ethical Engineer* website provides a model for two approaches to assessment. This addresses the second research question: *Do students perceive benefits in sharing perspectives on a digital medium, across national boundaries, and for their development as engineers?*

Surveys. One approach that has been used to address this question is to survey students regarding their website experiences, which consisted of commenting on ethical dilemmas in engineering, presented as case studies. Results from recent surveys have been promising, as suggested by students' responses to three key questions, where a 5 shows strong agreement with the question and a 1 shows weak agreement with the question:

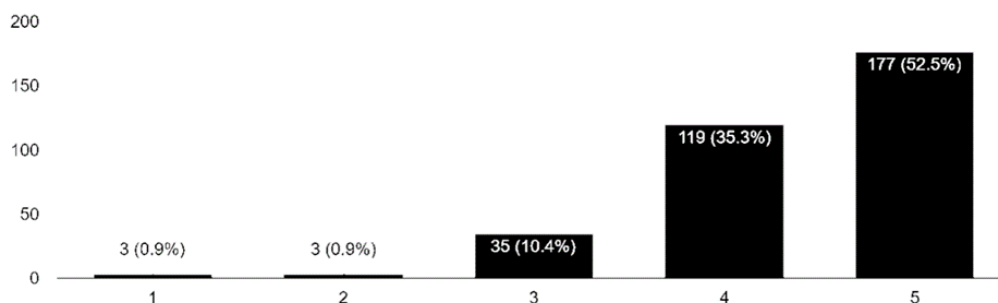
How relevant to your course curriculum were the case studies?

337 responses

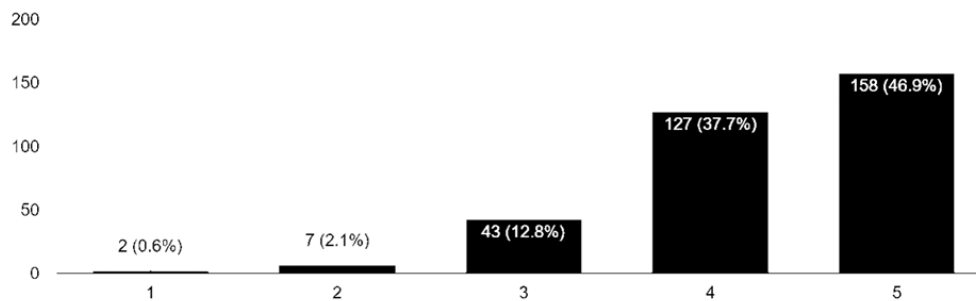


How engaged were you with the task of commenting on the case study?

337 responses



How helpful to your preparation as a professional was reading and commenting on the case study?
337 responses



Responses to these three survey questions strongly suggest that students regarded the website experience as relevant to training in their discipline and preparation as professional engineers. Students also provided open-ended responses to the question: *Please provide additional comments*. Below are sample responses.

Sample Comments Related to Academic Development

Ethics is inescapable. By reading these three case studies and the curriculum, I have learnt a deeper side of ethics and what it is to be ethically right and articulating our own values.

It was a great experience studying the case studies and putting my own view on it, and engaging in this activity had also helped to build an insight on the topics provided.

It was a fun experience, and reading other comments was also quite insightful.

It has been a neat experience, which I enjoyed a lot. I would love to be a part of such enriching endeavors again.

Hopefully we have this course in the next semester as well as this course exposure to reality of behavior.

It was really a great experience indeed, we got to learn about the different incidents & shared our comments on various scenarios.

This is a very good platform where one can explore and learn new things.

Sample Comments Related to Development of Global Competence

Great initiative to make students aware about the current global situations that are giving the red signal for environment.

The case studies gave in-depth information about the serious issues of the world that need to be considered immediately and also to rectify the mistakes that have occurred in the past so that our future generations do not suffer due to such mishaps.

These case studies give us professional knowledge and develop a courage in me to put my own opinion in this platform. It's a very knowledgeable way to know others' opinion and put comments on that and heeding it will be great when each and every person will understand the safety requirements and follow all instructions.

The case studies really call for critical and lateral thinking. And it feels that the world is in our hands.

Qualitative Analysis and Automatic Feedback

A second method of analyzing students' comments to the case studies posted to the *Ethical Engineer* website has been through a combination of human and machine methods of text analysis. The goal of these analyses has been to identify key themes in students' reasoning about ethical issues and then to provide students with feedback on their treatment of those themes. The first step in these analyses was to classify students' comments based on key themes that were identified in advance by the course instructors. In the next step, the human classifications were submitted to a naïve Bayes classifier in order to train the classifier to identify themes based on the human classifications. In the final step, the naïve Bayes classifier was interfaced with the *Ethical Engineer* website in order to provide automatic feedback to website participants upon submitting a comment. The automatic feedback provides students with a measure of the extent to which they addressed the key themes in their comment. In addition, based on the naïve Bayes analysis, the website offers students writing suggestions for more comprehensive coverage of key themes.

To develop the naïve Bayes classifier for the *Ethical Engineer*, human raters assigned a topic to approximately 3000 sentences from 300 comments submitted to the website, with inter-rater agreement of approximately 87%. These training texts were used to test a range of classification models, ultimately choosing a Bernoulli Naïve Bayes classifier. Across multiple tests of the Bernoulli Naïve Bayes classifier using a 70-30 ratio for training and testing, the classifier was shown to agree with human raters at a rate of approximately 78%. When surveyed regarding their reactions to the automatic feedback, participants indicated that the feedback was moderately to very informative and that they agreed with it moderately to very much.

Developing the *Petroleum Engineer*

We have initiated development of the *Petroleum Engineer*. The website has been launched and is functional, as shown in this image from the homepage:



The Petroleum Engineer

Welcome to the Petroleum Engineer

The Ethical Engineer brings together multiple academic institutions and organizations to discuss the

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An effective way to develop knowledge and action in students is through discourse, that is, by giving students a chance to make judgments, to explain them, and to compare them with those of other students [4] and an effective way to develop an awareness of world problems and appropriate actions is through a case study method of instruction [5]. Loui [6] found that the two most influential activities in the ethics course he taught was exposure to diverse perspectives about moral questions and problems through the analysis of everyday scenarios and cases like the Challenger disaster. These several studies confirm the effectiveness of case-study learning. The *Petroleum Engineer* project uses case studies as the primary learning material. Students compose and share their reactions to the case studies and to other students' reactions on the website.

Student responses on the website are not completely open-ended. In order to make students responses amenable to qualitative analysis, as described earlier for the *Ethical Engineer* website, and, further, the ability to automate feedback to students, a guiding structure, or scaffold, must be provided to students as part of the process of composing a response to an ethical dilemma. Guidance is provided to students through guiding questions. These questions relate to the course themes regarded as key topics by the participating course instructors. In the initial test of the *Petroleum Engineer*, five themes will be used to guide students: 1) stakeholders, 2) knowledge and skills required for innovative global solutions, 3) interdisciplinary innovative solutions, 4) cultural insights, and 5) personal position regarding what is ethically right. The themes are not fixed and will evolve, with associated scaffolding, as students contribute comments to the website and instructors assess their merit and validity.

Current Challenges in Global Education

Here we address the third research question: *How important is it, from an educational perspective, for educators and students to interact with and collaborate with peers in other countries?* Nations have become globally interdependent. Successful cross-national relations now and in the future depend on an understanding and appreciation of geographic, economic, social, and cultural differences. *Global competence* has been within the discourse of the engineering community in the US and Europe for at least 30 years [1]: "Global competence is among the new skills and abilities needed for all graduates to live and work knowledgeably and comfortably in a transnational economy and global society, especially for engineers." What defines global competence, how do we instill it, and how do we assess it? Addressing these issues requires one to acknowledge the ethno-diversity in today's world: "To thrive, future

engineers will have to be able to work productively with radically different cultures, educational backgrounds, technical standards, quality standards, professional registration requirements, and time zones” (p. 46) [7].

Van den Hoven [8] describes the need for *comprehensive engineering*, wherein engineers “cannot focus on only one technical or any other aspect in isolation, but must adopt a wider and multidisciplinary perspective of these systems, including an ethical and social perspective” (p. 1789). One path to comprehensive engineering among current engineering initiatives and resources involves intercultural skills. Intercultural knowledge and competence is “a set of cognitive, affective, and behavioral skills and characteristics that support effective and appropriate interaction in a variety of cultural contexts” [9]. It is “the ability to think and act in interculturally appropriate ways” (p. 422) [10].

Hammer and colleagues [10] have developed an assessment instrument for intercultural competence: the Intercultural Development Inventory (IDI). At the upper skill levels, the IDI assesses an Acceptance factor. Hammer et al. are careful to distinguish *acceptance* from *agreement*: To accept the relativity of values to cultural context (and thus to attain the potential to experience the world as organized by different values), people need to figure out how to maintain ethical commitment in the face of such relativity” (p. 425). That is to say, recognizing and accepting cultural diversity does not minimize ethical and moral responsibility.

Our current initiative using a shared digital platform, the *Petroleum Engineer*, may help to reduce gaps in understanding others’ perspectives, which is absent in a traditional mode of classroom teaching owing to limited or no cross-national participation. Initiatives like this could develop cross-cultural sensitivity among future petroleum engineers across the globe for more pragmatic solutions to numerous problems that nations face today. The *Petroleum Engineer* promises knowledge sharing and active participation in resolving ethical dilemmas in a social setting, using an online university platform, through an ongoing collaborative project. The idea behind the collaboration is to offer a constructive way to deliver experiential learning, that is, learning through reflection on doing [11]. The *Petroleum Engineer* website provides petroleum engineering students opportunities to develop socio-cultural and ethical reasoning skills through reflective deliberations in a global context.

Developing a sense of ethical leadership in students may be a crucial component in developing successful engineers: “Ethical leadership represents such a life-preserving ethos. It is not an inward-looking, isolating attitude, but rather the cultivation of values that uphold the humanity in each individual and the interrelatedness of all humans with the living world.”¹ The concept of ethical leadership is not meant to apply to someone else, but rather to each individual engineer working in a complex world. The situations, locations, experiences, and even the worldviews engineers hold, may vary. As ethical leaders, though, they share and promote a common moral sense and apply their technical skills to support communities in varied settings and circumstances. Whether the pedagogical resource provided to engineering students through the *Petroleum Engineer* will contribute to the development of global competence and intercultural sensitivity is a question we are currently addressing through this project.

¹ <https://www.globethics.net/blogs/-/blogs/restorative-hope-and-ethical-leadership-in-times-of-natural-catastrophes>

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