



Integrating professionalism in a project-based engineering curriculum

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Abstract

Professionalism has been an important component of engineering education not only in the eyes of industry but also the Accreditation Board for Engineers and Technology (ABET). In a project-based learning environment where students are highly motivated, professionalism can be easily integrated into the curriculum. Iron Range Engineering, a newly established project-based program, has given considerable attention to professionalism and has incorporated professionalism in the curriculum as a course series. In this paper, we discuss the Iron Range Engineering program, professionalism activities, ABET outcomes associated with professionalism and the integration of professionalism in the curriculum.

1- Introduction

Since the publication of Engineer 2020¹ (and before) and the modification on accreditation criteria made by ABET, professionalism has been an important subject in the engineering education^{2,3}. The expectations of engineers have been changing due to the changes in technologies, societies and the global economy². Nowadays, engineers are expected to be competent in both technical and professional skills. It has also come to the attention of many engineering institutions to implement professionalism as a part of their engineering curricula.

Project-Based Learning (PjBL) is a learning method in which students learn their technical knowledge in the context of an industry or faculty-defined project^{4,5,6}. Moreover, PjBL provides an active learning environment and increases students' interests and motivations⁷. PjBL not only enables students to practice self-directed learning and to find sustainable solutions to design problems, it creates opportunities for students to recognize that they are part of a global community, as well as teaches students communication (written, verbal, presentation), organizational, time management, self-assessment, engineering ethics, group participation and leadership skills⁷.

Iron Range Engineering (IRE), a complete project-based program, has realized the importance of professionalism and implemented professionalism as a part of the curriculum^{8,9,10}. The IRE students have to enroll and complete 12 credits of professionalism in their last two years of their Bachelor of Science in engineering. These 12 credits are divided into four courses called Professionalism I, II, III and IV. Each of these courses includes various components such as life-long learning, leadership, effective communication, teamwork, engineering ethics, community outreach, etc.

In this paper, we explain the activities, deliverables and outcomes of these professionalism courses. Additionally, we discuss how a PjBL program, such as IRE, can provide opportunities for students to learn and practice professional skills in the context of their team projects.

2- IRE Program

An innovative model for engineering education, called Iron Range Engineering (IRE), has been established in northeastern Minnesota since January 2010. The program is a result of collaboration between Itasca Community College and Minnesota State University, Mankato. The IRE model is a PjBL program where students learn technical and professional skills by working closely with industry on design or entrepreneurial projects which may lead to start-up companies. The IRE is an upper-division engineering program where IRE students are only juniors and seniors. They are usually graduates of local community colleges. They join the program after completing 68 credits of prerequisites.

The IRE curriculum consists of 60 credits of technical, professionalism, design and seminar. The IRE students must enroll in four design courses during the IRE program. Every student is given a chance to work on an entrepreneurial project at least once during their time at IRE. This helps students to learn business side as well as the engineering side of a project. Over the course of four semesters at IRE, the students are required to write four technical reports describing all aspect of the design projects in addition to writing business plan, personal improvement plan and experiment reports for all the technical competencies. The IRE students graduate with a Bachelor of Science in general engineering from Minnesota State University, Mankato.

The goal of the program is to producing graduates with significant integrated technical and professional knowledge and skills who will help the economic development of the region. The majority of the student learning occurs in the context of industry engineering projects, in contrast to the traditional distinctly topical engineering classes. The IRE program values skills such as strong teamwork, communication & leadership skills, a strong moral compass, ethics, cultural awareness and the ability to make good decisions.

The IRE students choose their own emphasis for the degree, by enrolling in specific competencies or projects. This enablement not only increases students' interests and motivation but also provides an environment for deeper learning and longer retention of the material. At IRE, there are no classes in the form of lecture halls; the students learn the contents relevant to their project. Each competency accounts for one credit. The learning material of a competency may differ for one student to another. The students choose what and when they want to learn and what technical evidence they may offer in support of their working.

3- Integration of professionalism in the curricula: ABET student outcomes

During the IRE program, students are expected to learn and practice a variety of professional skills. These skills include leadership, life-long learning, engineering ethics, professional responsibility, communication (verbal & writing), contextualization, contemporary knowledge of issues and teamwork. The IRE faculty have developed professionalism course series (I, II, III, IV) based on the ABET student outcomes and recent recommendation for a new look of engineers. More than half of ABET student outcomes are assigned to professionalism as follows:

Outcome D: an ability to function on multidisciplinary teams

IRE is a team-oriented learning environment where students work on their projects and technical learning as a team. The design projects are commonly multidisciplinary engineering problems. The IRE students with different emphasises form a team at the beginning of each semester to design a product or to recommend effective solutions. The IRE students must perform multiple teamwork assessments during semester and give comments to their teammate. At the end of each semester, they are required to submit an evaluation of their teamwork experience.

Outcome F: an understanding of professional and ethical responsibility

The IRE students are required to have a weekly meeting discussing ethical issues related to their projects. They must submit a summary of the discussion. They are also obligated to perform at least 15 hours per semester professional volunteer work for the community. Another requirement is the submission of personal improvement/evaluation assignment; the IRE students must write a reflection on their strengths and weaknesses with the help of other team members and the faculty.

Outcome G: an ability to communicate effectively

The IRE students must present their projects at least four times per semester; each of their presentations are evaluated and given proper feedback from both peers and faculty. Additionally, they must write and submit a number of technical reports and documents regarding their projects. All these documents are assessed and necessary criticisms are given. Moreover, they must participate in communication workshop every semester. Commonly, the program focuses on presentation skills in fall and writing skills in spring.

Outcome H: the broad education necessary to understand the impact of engineering solutions in global, economic, environmental and societal context

One of the design components is contextualization in which students are asked to investigate the significance their design may have on the environment, health and safety concerns, economics, ethics, etc. They must submit contextualization document at the end of semester.

Outcome I: recognition of the need for, and an ability to engage in life-long learning

A number of activities are available in this area. First, every IRE student is required to write a metacognitive memo for each single technical competency that he/she enrolled. In this memo, students must document learning process, learning quality, and changes in learning throughout the competency. Second, the students are also asked to prepare course materials and teach their peers. Third, the students must read / write academic papers and books about learning.

Outcome J: knowledge of contemporary issues

The IRE students are required to have weekly discussion about contemporary issues in the engineering field. A summary of these discussions must be submitted by the end of semester. They also must investigate if their projects are involved with any contemporary issue.

Outcome L: an ability to lead, manage people and projects

Multiple activities are available to the IRE students to learn leadership skills: the IRE students are expected to attend several workshops or given talks offered by well-known professionals in the leadership field. Additionally, the students are given opportunity to lead their project teams or student-life activities. They are also required to write a chapter each semester reflecting their experiences and plans in leadership.

Achieving these outcomes is easier in a project-based learning environment than traditional pedagogy. A typical IRE student must enroll in three credits of professionalism courses (Professionalism I, II, III, IV) each semester, 12 credits total during the program. All these courses have roughly the same syllabus, but students cover different material each semester.

4- Assessing the outcomes and effectiveness of the program in respect to professionalism

One of the questions to be answered is that if the IRE students actually achieve the desired outcomes. In order to assess the outcomes, a survey was conducted and sent to the direct supervisors who have supervised IRE interns or graduates. They were also asked to rate the IRE students or graduates compared to the interns/graduates they supervised from other institutions. A list of questions including both technical and professional performance was created. The professional criteria are as follows:

- Ability to function well on multidisciplinary teams
- Ability to act professionally and ethically responsible
- Ability to communicate effectively
- Ability to understand the impacts of engineering solutions in contexts such as environmental,
 - economic, societal, safety, etc
- Displays a recognition of the need for and ability to engage as an efficient learner

- Has adequate knowledge of contemporary issues
- Displays ability to lead and manage people and projects
- Engages in entrepreneurial thinking

Scoring guide was provided to employers as follows: scoring from one to five as one being significantly below and five being significantly above average in which average (three in figure 1) was defined as being the performance of graduates from other institutions. We received 23 responses from employers: 15 responses regarding our students who worked as interns and eight responses in respect to our graduates who are working as full time employees. The results of survey are displayed in figure 1. The results shows that our students excel in professionalism in compared with graduates from other institution.

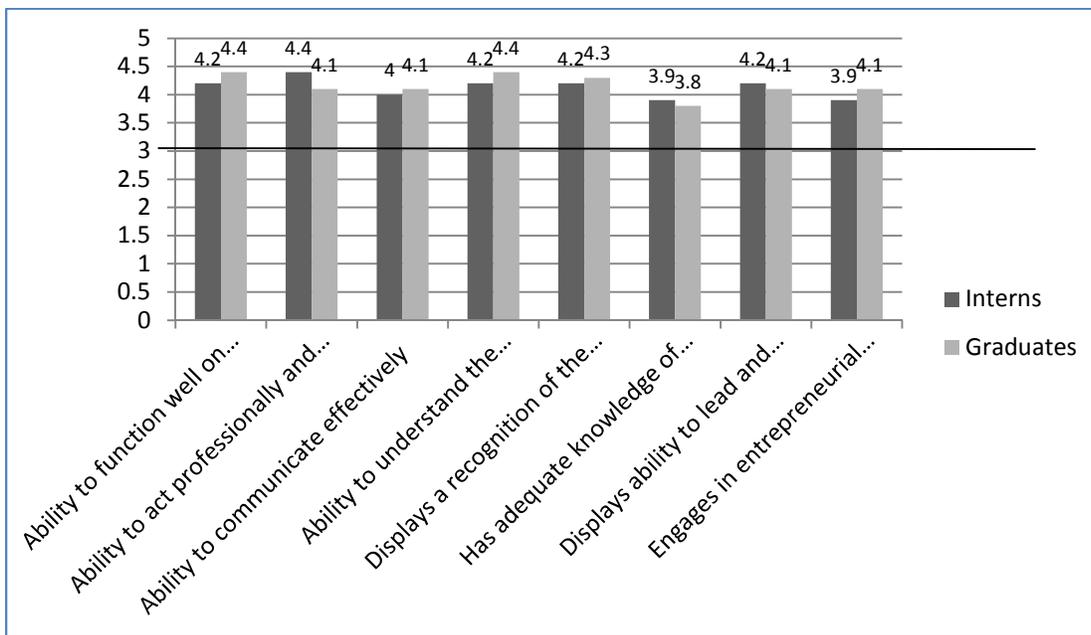


Figure1. Employer Satisfaction Survey.

5- Conclusion

In 21st century, engineers not only should have technical skills, they also must be armed professional skills to compete in national and global markets. The professional skills such as teamwork, communication, leadership, professional responsibility, and etcetera are necessary expertise for any engineers across the world. At IRE, we have recognized the importance of these skills and have implemented professionalism in the curriculum. The design of the course series was based on the ABET student outcomes. Tables 1 summarizes professionalism activities, deliverables and ABET student outcomes.

Table1. Professionalism activities, deliverables and outcomes

Professionalism	Activity	Deliverables	ABET Outcomes
Teamwork	Writing team contract Multiple teamwork assessment during each semester	Team contract Perform teamwork assessments Write a chapter on team work experience	D
Life-long learning	Documenting metacognitive memo for each competency Planning academic and semester learning Teaching peers Read and write papers about learning	Metacognitive memos Academic and Semester learning plan Paper summary	I
Communication	Writing multiple technical documents Presenting multiple presentations Participating in communication workshop	Final technical report Several presentations Writing workshop summary	G
Leadership	Participate in leadership workshop Read leadership books Leading a project team	Writing a chapter about leadership experience and plans	L
Ethics	Investigating and documenting ethical issues in the team project Weekly ethic discussion	Ethic summary paper	F
Contextualization	Investigating significance the design may have on the environment, health and safety concerns, economics, ethics, etc.	Contextualization Paper	H
Contemporary issues	Investigating Contemporary issues related to engineering field	Contemporary issues paper	J
Professional Responsibility	Performing outreach activities Personal improvement plan	Outreach paper Personal evaluation by mentor	F

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