Developing Student Professional Development Skills in Lifelong Learning and Engineering Standards

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Abstract:

To meet Accreditation Board for Engineering and Technology (ABET) standards, an engineering baccalaureate program must satisfy a list of criteria. The New Student Learning Outcome 7 requires “an ability to acquire and apply new knowledge as needed, using appropriate learning strategies” (ABET, 2018). Learning Outcome 2 requires students to develop "an ability to formulate or design a system, process, procedure or program to meet desired needs". The outcome measures a student’s ability toward lifelong learning. Rapid technological advancements require acquiring new skills, knowledge and competencies to succeed in the engineering profession. To develop competencies to meet the outcome, the University of Michigan-Flint developed and offered a series of workshops in collaboration with the library. These workshops are designed to meet once a week for seven weeks. Each workshop presented topics about how to keep up with current research, explore engineering standards, and incorporate latest technological developments in the engineering design and processes. The objective of these workshops was to advance their knowledge and professional skills by providing students with information about different engineering standards. Students are also required to write a research paper by selecting a topic relevant to their engineering courses. After completing the workshops and the research paper, students completed a survey on the importance and relevance of the topics learned from the workshop. Results of this pilot study will be assessed to evaluate future workshop topics to improve students' knowledge and competencies in the area of engineering professional skills.

Introduction:

ABET accreditation requires students to develop knowledge and skills in mathematics, science, engineering topics, and professional skills such as information literacy and communication [1]. Most programs put a larger focus on knowledge developed through coursework, but professional skills are not systematically incorporated in the curriculum although professional skills are extremely important for meaningful employment. To prepare graduates for engineering professions, the University of Michigan-Flint developed a professional skills workshop for engineering students. The workshop consists of seven hours of weekly sessions considering topics that are important but not presented in any courses. The workshops included three important areas: engineering standards, investigating the current state of technology by performing research on an engineering topic, communication skills, lifelong learning, etc.

A survey was conducted with participants of the workshop and students who did not participate as participation in the workshop were voluntary. The survey questions were carefully prepared to determine whether there is a correlation between how students view the importance of professional skills and if they are satisfied with how the current engineering curriculum is helping them develop professional skills.

Literature Review:

The Tandon School of Engineering of New York University developed a series of workshops called Student to Scholar, to prepare students with professional skills [2]. A survey was conducted after the workshop to determine the effectiveness of the workshops. The workshop topics were focused on research and communication skills development as elements of professional skills. The Engineer of 2020 Project centers on an effort to envision the future and to use that knowledge to attempt to predict the roles that engineers will play in the future [3][4][5]. The current study included engineering standards, lifelong learning in addition to research and communication skills as these are considered important professional development skills. Frankel described the discrepancy between how some criteria, like "an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics", receive most of the focus in engineering in education while others receive less than ten credit hours. [2]. A study by Kirkpatrick et al. [6][7], concluded that current engineering education programs put minimal emphasis on professional skills and that giving these skills a greater focus would be helpful to prepare students for future careers. This, in turn, would make the engineering field more accessible to students. Another study by Holloway et al. evaluated a few KSA (knowledge, skill, and ability) frameworks and reported that the frameworks compared had similar expectations for student outcomes, problem-solving, communication, and teamwork. Given how the ABET framework can put minimal emphasis on professional skills, other frameworks could have similar problems. [8] The essay "Soft Skills for The New Economy: Their Place in Graduate Education in Engineering and Engineering Technology" states that graduates need to be educated in professional skills to succeed in their careers. [1]

Research Methods:

Recognizing the need for the development of professional skills among engineering students, a pilot study was conducted at University of Michigan-Flint mechanical engineering department. The study involved the development of workshops in collaboration with the librarians to improve important knowledge and skills that are not attained by regular course work in the curriculum. A series of workshops were offered over seven weekly sessions where students were assigned to write a research paper relevant to their engineering courses. Students who attended the workshops and prepared the research paper were offered extra credits for their courses. The workshop topics covered how to find relevant previous research, introduction to engineering standards, ethics, lifelong learning and how to write a research paper. After completion of the workshop, a survey was conducted to assess the outcome. The survey questions were divided into four areas: research experience, lifelong learning, ethics, and engineering standards as these topics were covered in the workshop. The survey used a five-point Likert scale to collect responses from the participants. Each survey question sought a response about how important they thought a skill or concept was and how satisfied they were with the engineering curriculum in developing the skill. The demographic information: gender, class standing, and age were collected to compare students from different backgrounds. The survey responses were collected from students who participated in the workshop and who choose not to participate.

The survey responses were analyzed for each question comparing the experimental group and control group of students to evaluate the following research questions.

a) There is no significant difference in importance and satisfaction between students who

attended and those who did not attend.
b) There is no significant difference in importance and satisfaction between students from different class standing, age, and gender.

Data:

A total of 38 students responded to the survey questions, of which 6 of them attended the workshop, 28 of them did not attend, and 4 students did not respond. There were 31 males and 6 females with the following class standing: 1 sophomore, 22 juniors, and 14 seniors. Students were grouped in three different age groups: 29 students between 20-25, 6 students were between 26-35, and 2 students between 36-44.

Table 1: Student Demographic information

		gender		Total
		Male	Female	
Class standing	Sophomore	1	0	1
	Junior	18	4	22
	Senior	12	2	14
Total		31	6	37
		gender		**Total**
		Male	Female	
Age group	20-25	25	4	29
	26-35	4	2	6
	36-45	2	0	2
Total		31	6	37

The four sections of the survey questions included three questions in each section with a total of 12 questions. The participants were asked to answer how important they thought the corresponding ability was and how satisfied they were in their skills corresponding to said ability. For each section, a maximum composite score of 15 was calculated by adding the sum of the responses from the 3 questions. A composite score for each section as well as for the whole questionnaire is calculated based on students' responses on their self-reported survey. The scores from each of the 4 sections were then added together, creating a composite score out of 120 points. The composite score was used to determine the student's self-assessment of their professional skills.
The one-way analysis of variance (ANOVA) was used to determine whether the mean of the dependent variable is the same in two or more unrelated, independent groups. However, it is

typically only used when three or more independent, unrelated groups are present since an independent-samples t-test is more commonly used when just two groups are present. If two independent variables are present, a two-way ANOVA can be used. Alternatively, if multiple dependent variables are present, a one-way ANOVA can be considered.

A One-Way ANOVA was performed, comparing the composite scores of students who attended the workshop with students who did not. The test results showed no significant difference between these two groups. Table 2 shows the level of significance (p-value) for importance and satisfaction in all four areas. No significant differences were observed with the lowest significance value of P = 0.157 (p >0.05) for satisfaction in research experiences. This indicates that there are some differences in satisfaction between these two groups. This p-value is too large to conclude a correlation. The corresponding F value was F (1, 32) = 2.102

Table 2: Results of one-way ANOVA between student composite score and each criterion

	Importance				**Satisfaction**			
Criteria	Research Experience	Lifelong Learning	Ethics	Engineering Standards	Research Experience	Lifelong Learning	Ethics	Engineering Standards
F	F(1,31)=0.006	F(1,31)=0.708	F(1,32)=1.655	F(1,32)=0.179	F(1,32)=2.102	F(1,31)=0.386	F(1,31)=1.141	F(1,30)=0.535
P	0.939	0.407	0.207	0.675	0.157	0.539	0.294	0.47

A One-way ANOVA was performed for each of the four sections comparing demographic information such as gender, class standing, and age. Significant differences were observed in importance among students from different class standing (p = 0.037 < 0.05) and different age groups (p = 0.004 < 0.05). Nearly significant differences were observed in the importance of research experience among students from different class standing (p = 0.065) and satisfaction of research experience among different age groups (p =0.068. The ANOVA results are summarized in Table 3.

Table 3: Significant Results of one-way ANOVA

Criteria	**1. Class standing: Importance of research experience**	**2. Class standing: Importance of engineering standards**	**3. Age group: Satisfaction of research experience**	**4. Age group: Satisfaction of Lifelong Learning**	**5. Gender: Satisfaction of Ethics**
F	F(2,33)=2.972	F(2,34)=3.651	F(2,34)=2.917	F(2,34)=6.583	F(1,34)=2.889
P	0.065	0.037	0.068	0.004	0.098

The mean composite scores of class standing, age group, and gender are reported in Figure 1. It was observed that junior students reported higher importance on research experience and engineering standards while sophomores and seniors reported lower importance. Differences were also observed between age groups and satisfaction in research experience and lifelong

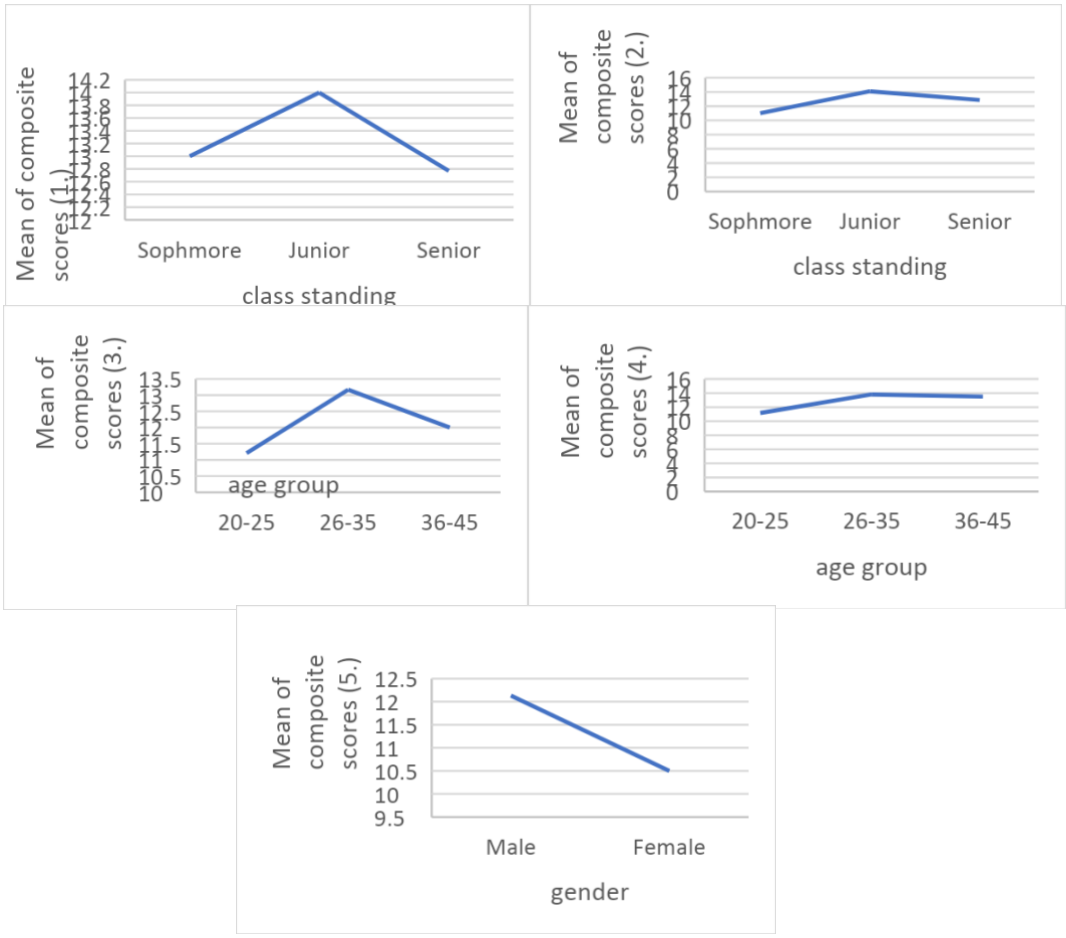

Figure I. Means plots of Significant data

learning. A significant difference was found between gender and satisfaction in ethics.

Discussion:

The current study investigated the importance and satisfaction of students in four areas of professional skills: research experience, lifelong learning, ethics, and engineering standards. A survey was used to obtain responses from students about the importance and satisfaction of professional skills in these four areas. Survey Responses were collected from students who attended the professional skills workshop and who did not attend. Statistical analysis results showed no significant difference between how the two groups viewed the importance of professional skills or engineering standards and their level of satisfaction. However, the results indicated that Juniors were more satisfied with their knowledge and ability to be lifelong learners, with their skills in research and placed higher importance on having the capabilities to do research. Students from different gender showed a difference in satisfaction of ethics however due to a smaller sample size of female students (6 female students) the results may be skewed.

The limitations of the current study included smaller sample size, as a number of students did not participate in the survey. In addition, the accuracy of student self-reporting may not be reliable,

as some students' may not be fully aware of these four areas of professional skills needed by employers. During the next phase of the project, more information will be provided about the importance of professional skills and encouraging more students to participate in the workshop. The sample also had other limitations such as disproportionately low number of female students and only one sophomore student in the study. The study will be extended to students from different class standings in the future.

Conclusion:

To assess students' perception of the need for professional skills, a pilot study was conducted among engineering students at the University of Michigan-Flint. A seven-week workshop was developed by engineering faculty and university librarians to provide knowledge and skills in four areas of professional skills that are important for engineering students: research experience, lifelong learning, ethics, and engineering standards. After completion of the workshop, a survey was conducted to assess students' perceptions of importance and satisfaction in these four areas of professional skills. Statistical analysis results of the survey data showed a correlation between how students view the importance of professional skills. Different groups of students based on age, gender, and class standing had different perceptions of importance and satisfaction in professional skills. However, the data shows no correlation between the scores of those who attended the workshop and those who did not.

The pilot study participation was voluntary for student participation that may have resulted in a lower number of students. Integrating professional skills development modules in core courses such as Introduction to engineering or engineering design courses will increase participation of more students . The results of this study will be used to further the knowledge, skills, and abilities of students in the areas of professional skills (engineering standards, research, lifelong learning, ethics, communication skills) that are important for success as professional engineers.

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Professional Skills Development Workshop Survey

Gender (Male/Female) Class Standing: (Freshmen/Soph. /Junior/Senior)
Age:_ Date:_

	Importance					Satisfaction				
Questions	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree	Very Satisfied	Satisfied	No Opinion	Dissatisfied	Very Dissatistfied
Section 1: Research Experience										
1.1 Having the knowledge and skill necessary to investigate new problems.										
1.2 Understanding current body of knowledge that can be used to develop new approaches to problem solving.										
Ability to develop solutions with appropriate methods and data.										
Section 2: Lifelong Learning										
Recognition of the need to continue developing one's skill after graduation.										
Understanding of the need to learn new professional skills in the workplace over the course of a career.										
Familiarity with methods to teach oneself new skills after graduation.										
Section 3: Ethics										
Recognition of engineering responsibilities and proper consideration of impact.										
Understanding of the importance of giving others credit for their contributions.										
Having an ability to internalize meanings from other sources and explain it in own words.										
Section 4: Engineering Standards										

Recognition of the need for knowledge of applicable engineering standards.											
Familiarity with engineering standards for optimal design to meet desired goals.											
Recognition of the importance of standards for safety, reliability, and health/societal needs.											

Did you attend the Engineering Professional Development Workshops? □ YES □NO