Exploring Enculturation in the First-Year Engineering Program

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Dr. Mendoza Diaz is Instructional Assistant Professor at the College of Engineering at Texas A&M University. She obtained her Ph.D. from Texas A&M University in Educational Administration and Human Resource Development and worked as a Postdoctoral Researcher with the Institute for P-12 Engineering Research and Learning-INSPIRE at the School of Engineering Education-Purdue University. She was a recipient of the Apprentice Faculty Grant from the Educational Research Methods ASEE Division in 2009. She also has been an Electrical Engineering Professor. Dr. Mendoza is interested in Socioeconomically Disadvantaged Engineering Students, Latino Studies in Engineering, and Entrepreneurship in Engineering Education.

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So Yoon Yoon, Ph.D., is an assistant research scientist at Institute for Engineering Education and Innovation (IEEI) within the Texas A&M Engineering Experiment Station (TEES) and Texas A&M University. She received her Ph.D. and M.S.Ed.in Educational Psychology with the specialties in Gifted Education and Research Methods & Measurement, respectively from Purdue University. Her work centers on P-16 engineering education research, as a psychometrician, program evaluator, and institutional data analyst. She has authored/co-authored more than 30 journal articles and conference proceedings and served as a reviewer of journals in engineering education, STEM education, and educational psychology, as well as an external evaluator and an advisory board member on several NSF-funded projects.

Dr. Jacques C. Richard, Texas A&M University

Dr. Richard got his Ph. D. at Rensselaer Polytechnic Institute, 1989 & a B. S. at Boston University, 1984. He was at NASA Glenn, 1989-1995, taught at Northwestern for Fall 1995, worked at Argonne National Lab, 1996-1997, Chicago State, 1997-2002. Dr. Richard is a Sr. Lecturer & Research Associate in Aerospace Engineering @ Texas A&M since 1/03. His research is focused on computational plasma modeling using spectral and lattice Boltzmann methods for studying plasma turbulence and plasma jets. His research has also included fluid physics and electric propulsion using Lattice-Boltzmann methods, spectral element methods, Weighted Essentially Non-Oscillatory (WENO), etc. Past research includes modeling single and multi-species plasma flows through ion thruster optics and the discharge cathode assembly; computer simulations of blood flow interacting with blood vessels; modeling ocean-air interaction; reacting flow systems; modeling jet engine turbomachinery going unstable at NASA for 6 years (received NASA Performance Cash awards). Dr. Richard is involved in many outreach activities: e.g., tutoring, mentoring, directing related grants (for example, a grant for an NSF REU site). Dr, Richard is active in professional societies (American Physical Society (APS), American Institute for Aeronautics and Astronautics (AIAA), etc.), ASEE, ASME. Dr. Richard has authored or co-authored about 25 technical articles (19 of which are refereed publications). Dr. Richard teaches courses ranging from first-year introductory engineering design, fluid mechanics, to space plasma propulsion.

Dr. Tanya Dugat Wickliff, Texas A&M University

Delivering significant results in pivotal roles such as Sr. Consultant to high-profile clients, Sr. Project Manager directing teams, and Executive Leader of initiatives and programs that boost organizational effectiveness and optimize operations have been hallmarks of Dr. Wickliff's career spanning more than 24 years with leaders in the oil & gas and semiconductor industries.

As an expert in the areas of Executive Leadership and Team Development, Strategy Design & Execution, Supply Chain Optimization, Change Management, System Integration and LEAN Process Improvement (technical and business), Dr. Wickliff is passionate about Organizational Wellness and the Holistic Wellness of individuals. She is also a professional Facilitator and Motivational Speaker.

Dr. Wickliff earned a PhD in Interdisciplinary Engineering from Texas A&M University where she combined Industrial Engineering and Organizational Development to conduct research in the area of talent

management and organizational effectiveness. She also completed an executive MBA from the University of Texas-Dallas and a BS in mechanical engineering from the University of Houston. She is founder of a nationally recognized pre-college initiative program, FreshStart, which has served more than 2000 students since its inception.

Dr. Wickliff is blessed to work daily in the area of her passion – developing young professionals – in her role at Texas A&M University. She is the Director of the College of Engineering's, Zachry Leadership Program and a Professor of Engineering Practice. At Texas A&M University, she has taught Capstone Senior Design and Foundations of Engineering courses, but now teaches Engineering Leadership Development courses. She has also taught Project Management and Risk Management courses for the University of Phoenix.

Dr. Wickliff has been honored with University of Houston's Distinguished Young Engineering Alumni Award, the Black Engineer of the Year Career Achievement Award for New Emerging Leaders and featured in several publications. She has presented keynote addresses, facilitated workshops and given motivational presentations at numerous civic and corporate forums domestically and internationally. She is a contributing author to Tavis Smiley's book, "Keeping the Faith", with her inspiring life story. She believes that her life's calling and thus career quest is to be a catalyst of signicant, positive change and growth for individuals and entities. However, through it all, Dr. Wickliff gives top priority to her relationship with God, her husband Oscar Smith and her three sons – Jamar Dugat, Raymond Wickliff and Cortlan Wickliff.

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Abstract

Culture is defined as the set of beliefs, customs, and or arts of a particular group. Engineering enculturation can be defined as the process by which an engineering student learns the traditional content of an engineering culture and assimilates its engineering practices and values. The assimilation process to the engineering culture can be associated to engineering outcomes as defined by the Accreditation Board for Engineering and Technology (ABET) and through common outcomes among engineering programs, including first year engineering programs.

A group of professors at a university located in the southwestern region of the United States are conducting engineering enculturation research based on self- reported student's perceptions as well as performance indicators (i.e. grades) of at least 400 first year engineering students. Since publications and reports show that attrition is high during the first year engineering program, this inquiry seeks to explore the enculturation of individuals new to the profession. This paper presents preliminary data analysis of the pre-survey applied to the freshmen class during the fall 2016. Two different perspectives and subsets of data were included in this preliminary analysis. One from an open ended view of aspects valued by students as foundational to their enculturation process and the other based on a Likert-based set of questions.

I. Introduction

Enculturation is defined in this study as the process by which an individual learns the traditional content of a culture and assimilates its knowledge, practices, and values (KPV). Under such definition, ABET outcomes were transferred to a set of cultural constructs based on the content of the first-year engineering program. A depiction of such cultural constructs or traits is portrayed in Figure 1.

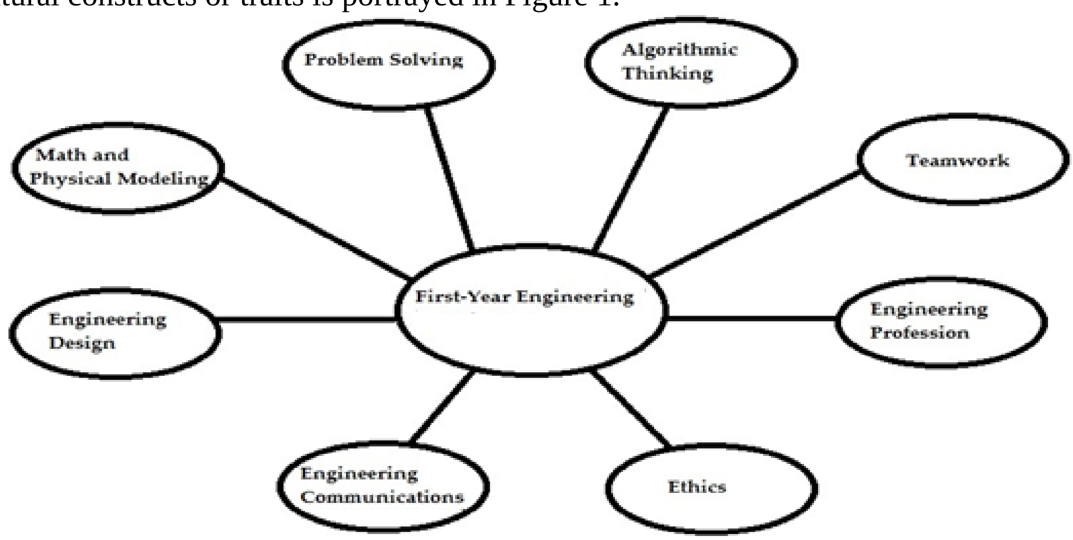

Figure 1. Schematic of outcomes from the course organization for the first-year engineering course.

II. Research Design, Analysis and Results

A. The open-ended analysis

The primary purpose of the open-ended study was to analyze student perspectives on how the process of engineering enculturation is occurring according to what is taught in a first-year engineering course. The three open-ended questions from a pre-survey that were the focus of this study seek the student views of how the engineering enculturation is occurring while they are in the course. The questions guiding this study are:

1. What is the contribution of the engineering foundational course in developing student's successful engineering knowledge, practices, and values during the semester?
2. What factors other than the course contribute to developing student's successful engineering knowledge, practices, and values during the semester?
3. What have you lost or retained about your own culture in favor of engineering culture?

A1. Participants and Analysis

The demographic composition of the survey participants is presented in Table 1. The dominant ethnic group was white male (75.27%) and Hispanics made up the next large body of students indicative of some diversity (27.5%), followed by Asians (9.3%). Women made up of 24.7%. Most of the respondents were American. The respondent pool is statistically diverse for the study with 40.1% minorities.

Table 1. Demographics of the participants (*N* = 182)

	Subgroup	*n*	%
Gender	Female	45	24.7
	Male	137	75.3
Race/Ethnicity	Hispanic	50	27.5
	Asian	17	9.3
	Black	6	3.3
	White	95	52.2
	Multiracial	5	2.7
Residence	Domestic	173	95.1
	International	9	4.9
Student Level	First-year	147	80.8
	Upper Level	28	15.4
	Branches/Academies	7	3.8
Total		182	100.0

Note. [a]Race/Ethnicity was categorized for domestic students only.

Two researchers of this study closely scrutinized students' raw responses to the three open-ended questions asking their views about their undergoing engineering enculturation. Inductive analysis and creative synthesis strategy were employed to analyze the responses. Researchers labeled and described the themes and calculated the frequency with which each theme appeared in students' raw responses.

A2. Results and Discussion

A.2.1 Contribution of the Foundational Course to Students' Engineering Enculturation

The first survey question explored students' perceptions of the contribution of the foundational course in their development of successful knowledge, practices and values (KPV). Dominating their answers was just acquiring the skills, knowledge, practices, values, and the ability of the course to set their foundations. Then they listed teamwork skills, problem-solving and programming and communication skills. The perception of the course as a "weed-out" was mentioned by one student. All students, whether male or female, indicate building skills as the most important item that they see as contributing to their engineering enculturation. This is more so than the statement of knowledge, practices and values in the definition of engineering enculturation provided to them.

Figure 2 shows the specific skills that dominated the student answers. The horizontal axis indicates the keywords of particular skills that emerged as important in their answers. Overall, **teamwork** was viewed as the most important skill. This was impressed upon students in class lectures and almost all in-class activities are conducted with students in teams: project-based coursework. The quizzes and exams are not by team. **Problem-solving** and **communication** skills were taught (and viewed by some students as helpful for good teamwork). Students were taught **programming** languages (or **coding** skills in a graphical and text-based languages) after some classes in algorithmic thinking or planning your code with flow diagrams or pseudo-code before coding.

Typical answers for the contribution of engineering foundational course to their skill development include:

> "*This course allows me to think both on my own as well as with team members to learn the course material given. It also challenges you in multiple ways to develop your character in the engineering program*."

> "*The engineering foundational course will likely contribute to my ability to function well on multidisciplinary teams since the group projects force me to work with unfamiliar people*."

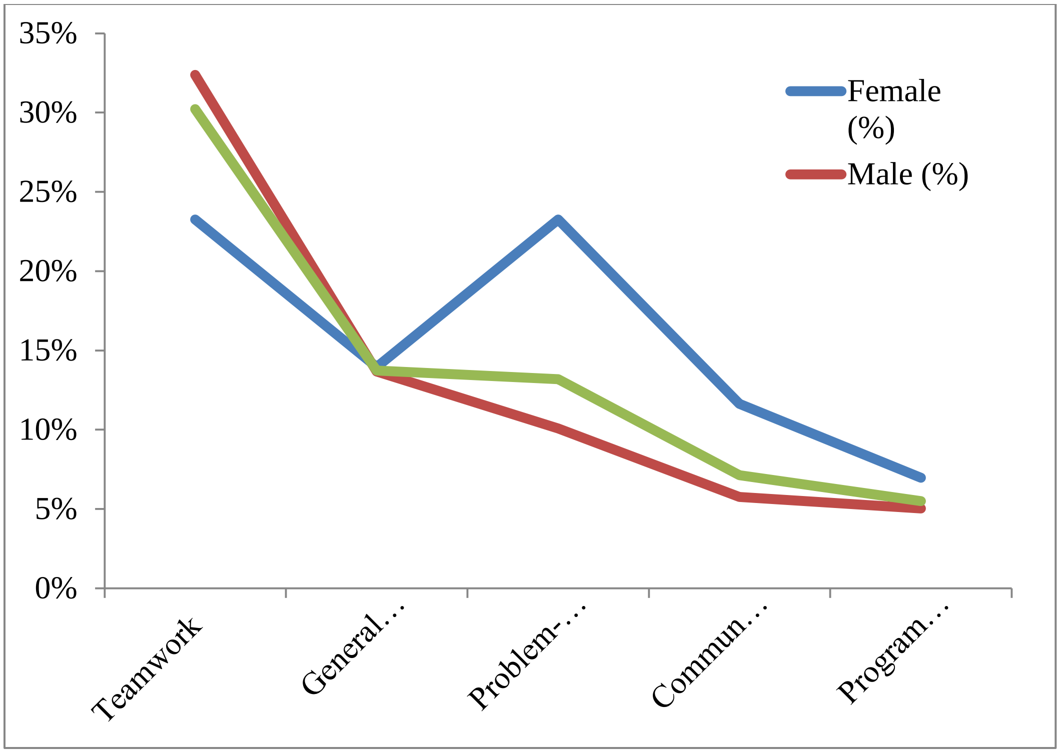

Figure 2. Contribution to the skills part of the student responses to their view of their view of the engineering foundational course's contribution.

A.2.2 Other factors that Contribute to Students' Engineering Enculturation

The second question asked and analyzed in the study was related to other factors outside the course that the students perceived as contributing to their engineering enculturation. The so-called "real-world experience" or internships, co-ops, research or exposure to professional practicing engineers dominated the answers. Interacting with friends, peers, whether in engineering or not, dominated in a few cases or emerged as a close second.

Figure 3 illustrates the responses when students were asked about other factors that impact their enculturation. The horizontal axis exhibits the themes that were most common in their answers: Real world indicates working out in the "real world" outside of the classroom in some companies as interns or co-ops or in research (though the students do not necessarily realize that research can be different). Interacting with others may be with friends, peers in engineering, whether in the first-year class or in at least one other course, where more knowledge may be acquired, and in extra-curricular activities (clubs, student organizations, society memberships, etc.). Some students felt that some personal characteristics (learning styles, learning ability, self/time-management, background, etc.) about themselves were the factors that would contribute other than the first-year course. Teamwork and communication were again mentioned mostly as being helpful in other courses or largely through projects (e.g., civil engineering canoe, mechanical engineering race car, the aerospace engineering model airplane or the multi-disciplinary or inter-departmental satellite, etc.).

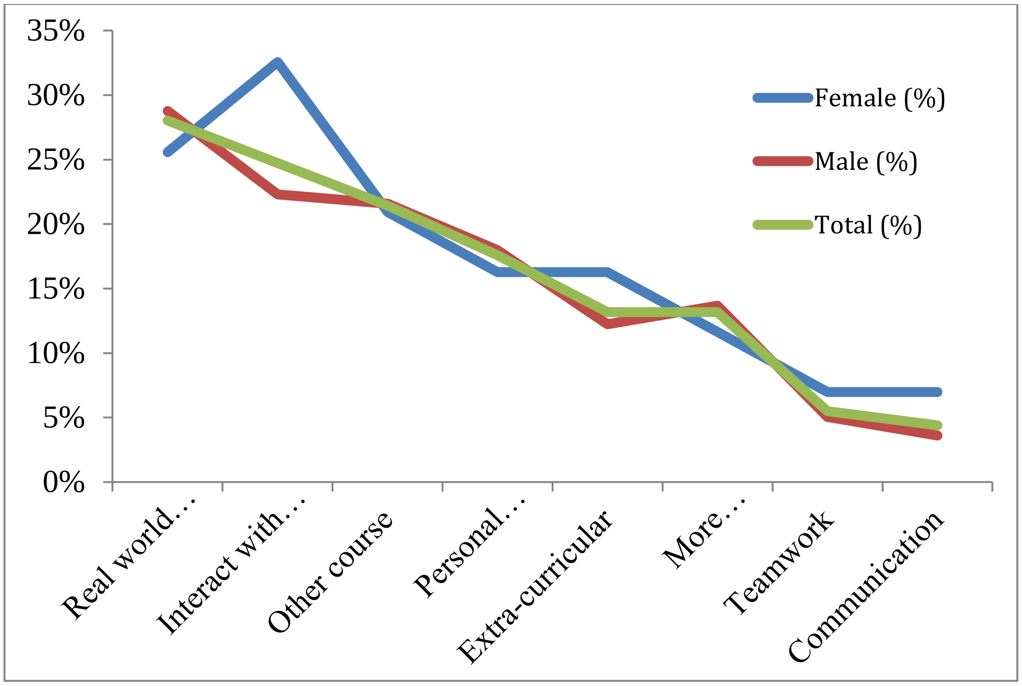

Figure 3. Other factors impacting development of student's successful engineering culture (knowledge, practices, and values) during semester. Gender breakdown.

Female students viewed their interaction with others as more important than male students, who viewed "real world experiences" as most important. Work in other courses was seen as important. Personal characteristics and experiences follow and some may be via extra-curricular activities, clubs, etc. Some of the personal characteristics include personal attitudes, work ethic, time management, self-management, other varied personal interests, learning ability, etc. Acquiring more knowledge, teamwork and communication skills, in other circumstances or outside the course, were not viewed as important as with the previous question. For example, typical answers include:

> "*More advanced engineering courses with longer projects and bigger pay-offs*."
>
> "*The school environment and being a member of the student body and many other student groups, leadership programs, and solving everyday problems in an efficient way all contribute to developing my engineering culture*."

Figure 4 focuses on the views of interactions with others. These particular interactions may be with other students and friends, peers in engineering, whether in the same class or not, not so much with professional engineers with whom that students could be working via internships or after they graduate, professors, whether in the first-year class or other courses, or family. Only a few students mentioned "role models" who are not necessarily closely related.

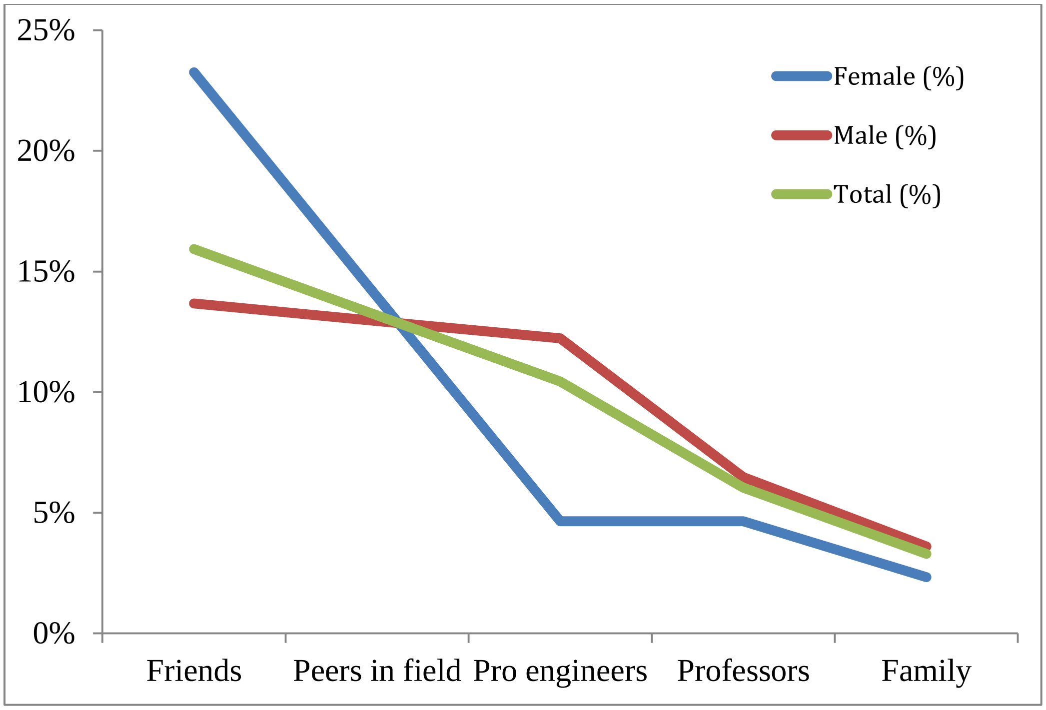

Figure 4. Greater detail on the contributors to the “interaction with others” in student responses to other factors impacting their enculturation.

The most important form of interaction was reported to be “with friends.” Even more notable there is how much more important that interacting with friends is to female students than to male students. Peers in the field, or working with them and talking to them then help their enculturation. The same goes for interacting with professional engineers and professors. Family members do not play that much of a role. Female students valued the importance of interacting with friends more than male students whereas males valued interacting with professional engineers more.

When it comes to what other factors outside of the course impact their enculturation, Figure 5 shows drastic differences between the first-year students and the upper-level students. Upper-level students attribute a lot more to their outside activities than first-year students. This is likely because upper-level students have had the time to build more connections to these outside activities than first-year students. An even bigger gap (~30%) exists in the valuation of interacting with others. The upper-level students have had time to make more connections around the university and would have more ability to make the best of these.

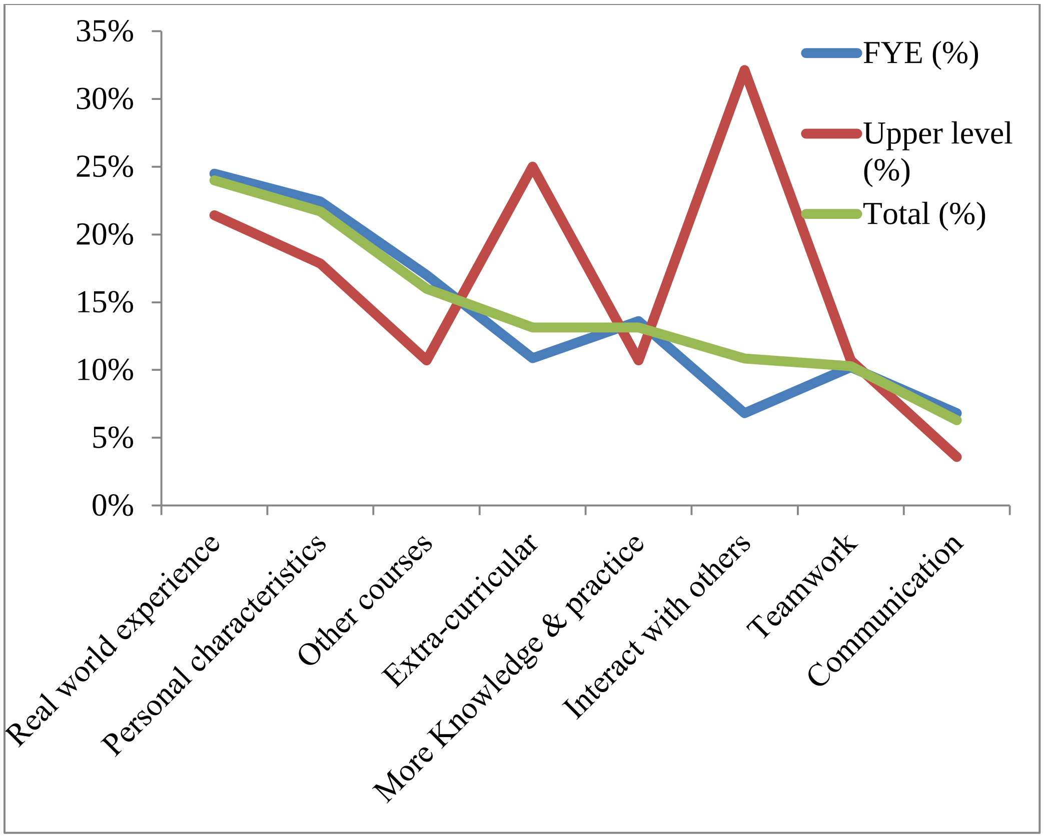

Figure 5. Other factors impacting development of student's successful engineering culture (knowledge, practices, and values) during semester.

Figure 6 details that even further in how much more the upper-level students value their friends and peers compared to first-year students. Both upper-level and first-year students value friends and peers more than connecting with professional engineers (e.g., via internship settings) or professors, etc.

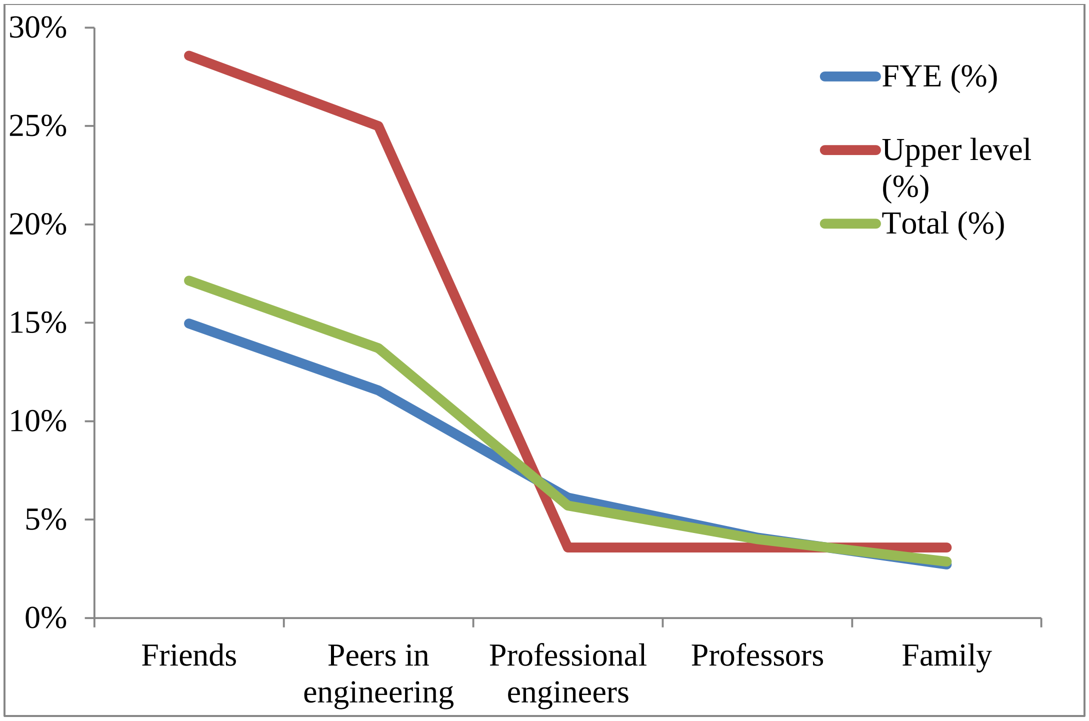

Figure 6. Greater detail on the contributors to the “interaction with others” in student responses to other factors impacting their enculturation

B. The Likert-based analysis

The primary purpose of this study was to analyze students' perceptions of their currant ability and corresponding academic success of the students in the Foundation of Engineering. The student participants were asked to self-report on their perceptions of their ability to perform the engineering student outcomes as set forth by ABET which align with the engineering enculturation outcomes that are taught in the first-year foundational engineering courses.

The associated pre-survey set of questions was presented to students as they were asked to self-report if they strongly agree, moderately agree, agree, were neutral, disagree, moderately disagree or strongly disagree. Table 2 provides details about these questions.

B1. Participants and Analysis

Although the survey was responded by more than 300 participants, only 187 completed the section related to the Likert-based questions. Table 3 shows a detailed description of the demographic information of participants in this study.

Table 2. Survey Questions

A. I have the ability to apply my knowledge of mathematics to solve engineering problems.
B. I have the ability to apply my knowledge of science to solve engineering problems.
C. I have the ability to design a system, component or process to meet desired needs within realistic constraints as an engineer.
D. I have the ability to function well on multidisciplinary teams as an engineer.
E. I have the ability to identify, formulate and solve engineering problems.
F. I have a good understanding of my professional and ethical responsibility as an engineer.
G. I have the ability to communicate effectively (oral and written) as an engineer.
H. I have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
I. I recognize the need for and plan to engage in life-long learning as an engineer.
J. I have knowledge of contemporary issues in engineering.
K. I have the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table 3. Demographics of the participants (*N* = 187)

Category	Subgroup	*n*	%
Gender	Female	43	23.0
	Male	144	77.0
Race/ Ethnicity[a]	Hispanic	52	27.8
	Asian	18	9.6
	Black	5	2.7
	White	98	52.4
	Multiracial	5	2.7
Minority Status	Minority (non-White)	75	40.1
	Majority (White)	98	52.4
Residence	Domestic	178	95.2
	International	9	4.8
Student Level	First Year	151	80.7
	Upper Level	28	15.0
	Branches/Academies	8	4.3
Total		187	100.0

Note. [a]Race/Ethnicity was categorized for domestic students only.

B2. Results and Discussion

Respondents reported a moderately high score of an average of 5.47 on a scale of 7.0 for all of the items. Students reported to be most confident about the following ABET student outcomes:

A. I have the ability to apply my knowledge of mathematics to solve engineering problems.
I. I recognize the need for and plan to engage in life-long learning as an engineer.
D. I have the ability to function well on multidisciplinary teams as an engineer.

The ABET student outcomes about which the students reported to be least confident were outcomes:

J. I have knowledge of contemporary issues in engineering.
H. I have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
C. I have the ability to design a system, component or process to meet desired needs within realistic constraints as an engineer.

Figure 7 shows the average scores of the eleven ABET outcome items recorded from all of the respondents.

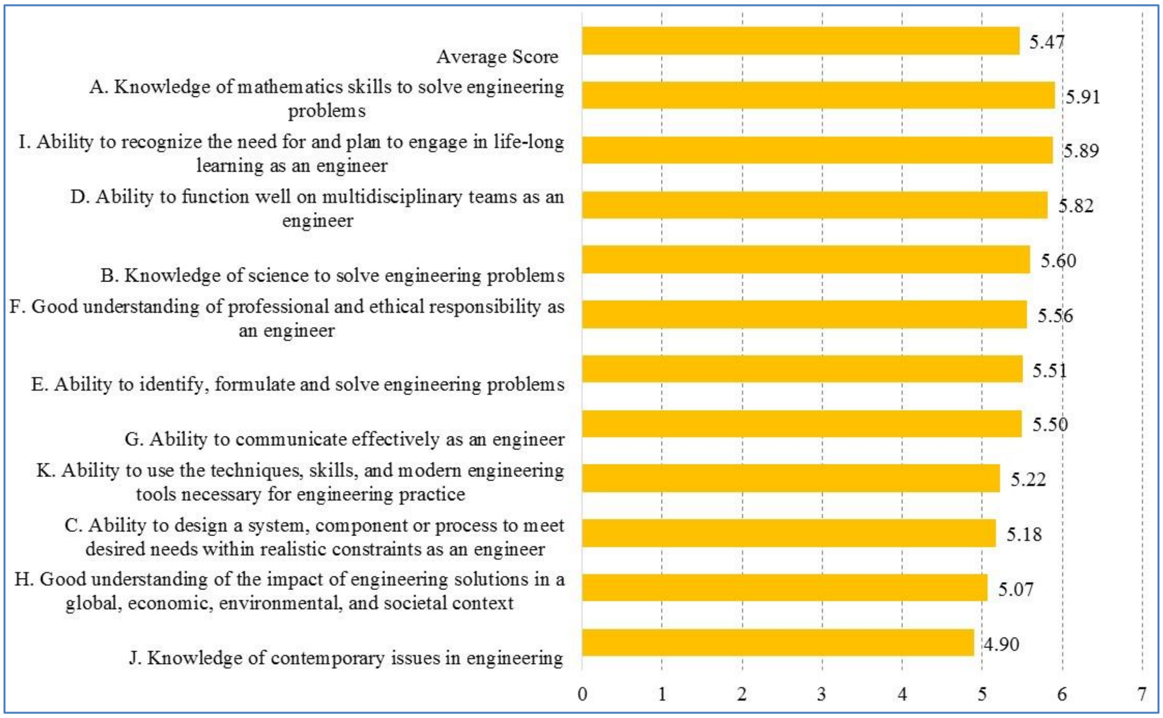

Figure 7. Students' Perceptions of their Ability on the ABET Outcomes

Ethnicity differences were not significant and only statistical significant differences were found between genders for the following items. Males scored higher than female students on three items (B, C, and E) but female students scored higher than male students on one item, K.

> B. Knowledge of science to solve engineering problems
> C. Ability to design a system, component or process to meet desired needs within realistic constraints as an engineer
> E. Ability to identify, formulate and solve engineering problems
> K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

III. Conclusions

This paper presents analyses of engineering enculturation constructs from two perspectives. (a) Open ended discussion of students' perceptions of the impact of the first-year engineering courses in their enculturation and (b) Quantitative analysis to the Likert-based questions related to ABET outcomes transferred to enculturation constructs.

Results show that gender differences occur in terms of perceptions of problem solving skills, interaction with friends. The same was found for non-white students versus white students. Upper level students tend also to differentiate themselves in terms of the contribution of the first-year engineering courses to their enculturation.

In terms of the quantitative analysis of perceptions, only gender differences appeared in items such as knowledge of science and engineering, ability to design a system, identification and formulation of solutions to problems, and ability to use techniques and tools necessary for engineering practice.

Although these are preliminary analyses, the results align to previous studies of professional practice and identity development. The focus groups analysis is underway and the pre-survey for the second semester is open and collecting data. Further investigation of these traits and constructs will help in the understanding of the professionalization of engineers viewed from an enculturating process.

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