Enculturation of Diverse Students to the Engineering Practices through First-Year Engineering Experiences

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; 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 30 technical articles (21 of which are refereed publications). Dr. Richard teaches courses ranging from first-year introductory engineering design, fluid mechanics, to space plasma propulsion.

Dr. So Yoon Yoon, Texas A&M University

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. Noemi V. Mendoza Diaz, Texas A&M University

Dr. Mendoza Diaz is Instructional Assistant Professor at the Dwight 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 for two Mexican universities. Dr. Mendoza is interested in Pre-college and College Engineering Readiness, Socioeconomically Disadvantaged Engineering Students, Latino Studies in Engineering and Computer Aided/Instructional Technology in Engineering.

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 significant, 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.
Enculturation of Diverse Students to the Engineering Practices through First-Year Engineering Experiences

Abstract

This paper presents the analysis of engineering enculturation constructs in the way that diverse groups are assimilated into engineering practices. The studies of socialization processes investigate the relationship of behavior, such as enactment-externalization to engineers eventually adopting proper work practices that are contrary to their pre-conceived notions of successful engineers. Therefore, studies of socialization processes, by which engineering students come into engineering practices, can provide impetus for further study about enculturation.

For example, in the workplace, communication and teamwork are highly valued. Yet many engineering students value individual accomplishment and competitiveness as the tactic to succeed. In this study, we gathered information about student expectations for the process to become an engineer, by learning engineering culture (knowledge, practice, and values) through the engineering foundation course, interaction with faculty, teaching assistants, and peers, and the other activities at the university.

We listed the engineering foundation course outcomes that are identified by the Accreditation Board for Engineering and Technology (ABET) and are also common to most of the engineering programs at most universities. Those can also be called engineering enculturation outcomes because students should exhibit characteristics of these outcomes at the end of the engineering program on their way to becoming a professional engineer. The study seeks to help understand how enculturation may contribute to the development of engineering students, who may particularly be from diverse backgrounds, adopting behavior and engineering practices favorable to their eventual success in the workplace.

I. Introduction

This paper presents the analysis of engineering enculturation of a diverse group of students into engineering practices. 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) (Richard et al., 2016). We gathered information about students and their expectations regarding the process to becoming an engineer, by their learning of engineering culture (knowledge, practice, and values) through the engineering foundation course, interaction with faculty, teaching assistants, and peers, and other activities at a southwestern institution (Mendoza Diaz et al., 2017; Wickliff et al., 2017).

The engineering foundation course outcomes are identified by the Accreditation Board
for Engineering and Technology (ABET) and are also common to most engineering programs at most universities (Engineering Accreditation Commission, 2015). Those can be also called engineering enculturation outcomes. Figure 1 shows the schematic of learning outcomes from the course organization at a southwestern public university.

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

A. Background

There have been limited studies on engineering enculturation of diverse students. Capobianco (2006) noted that women felt more like professional engineers when solving problems, working productively as a team and communicating effectively. Godfrey (2003, 2008) conducted extensive studies on engineering enculturation and has developed a model of the process. Stonyer (2002) did not specifically delve into enculturation as much as the impact of women interacting with others and her results suggested that the degree of interaction and adaptability of the women impacted their levels of successes. Miller (2007) sought to construct a bilinear multidimensional measurement model of Asian-American acculturation and enculturation and found the processes quite complex. Yoon et al. (2013) sought similar models in a more diverse pool and observed a greater tendency toward enculturation amongst Asian Americans than amongst African-Americans. Kim and Omizo (2006) sought correlations to self-esteem, attitudes, etc., but also found the relationships to be quite complex.

The studies of socialization processes investigate the relationship of behavior, such as enactment-externalization to engineers eventually adopting proper work practices that are contrary to their pre-conceived notions of successful engineers (Leonardi et al., 2009). Kowtha (2008) sought to capture the socialization in a model of the socialization process in a study focusing on gender in the engineering profession and his results suggested a team or workgroup interaction complementing the results of Stonyer (2002). The importance of teamwork in engineering and distinctions between male and female students have been noted by McAnear and Seat (2001).
B. Purpose of the Study

The primary purpose of the study is to analyze student perspectives on how the process of engineering enculturation is occurring according to what is taught in a first-year engineering (FYE) course that is to eventually lead to the practices and attributes of successful engineers. The study sought to examine students’ responses to a pre-survey to determine their pre-conceived notions of being an engineer and then to follow-up with post-surveys that would then help identify what engineering enculturation outcomes emerge as indicators of the occurrence of enculturation. We explicitly wanted to quantify what it is in the student responses would serve as evidence or indicators of occurrences of enculturation. We also sought to break down the responses by gender and race/ethnicity and whatever else emerges from the students’ own responses.

The three open-ended questions from a pre-survey that are the focus of this study seek the student views of how the engineering enculturation is occurring while they are in the course. The questions guided for this study are

1. What is the contribution of the engineering foundation 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?

II. Method

A. Setting

In fall 2016, over 3,600 students registered for a FYE foundation course at a southwestern university. The FYE program at this institution has undergone numerous changes. These revisions are well-grounded in research and best practices. The course is taught to all those first-year students in about 30 sections. Instructors manage consistency across several sections by starting with common bases of learning objectives that are aligned with ABET. Instructors also start with common sets of course lecture materials, quizzes and homework assignments. Each instructor may vary these materials according to their sections and teaching styles but follow the common learning objectives. The timing of presentation of course topics is set to adhere to the timing of the exams that strictly follow the learning objectives. The exams are common to all sections. This is regardless of how each section may have minor variations.

Two semester-long engineering foundation courses encompass the first-year engineering experience at this institution: Foundations of Engineering I and Foundations of Engineering II. The course goals for each course are listed as follows and Figure 1 shows the schematic of learning outcomes from the course organization.
Foundations of Engineering I - Course Goals:
1. Describe the engineering disciplines at a southwestern institution and the interrelationships among them as well as know what graduates of at least three disciplines of engineering do.
2. Individually, or as a member of a technical team, understand and apply a structured engineering problem solving using a design process.
3. Develop algorithmic thinking by implementing simple algorithmic forms of engineering models/problems using MATLAB.
4. Communicate technical information via written, oral, and visual communication tools.
5. Recognize the advantages and challenges of problem solving using a team.

Foundations of Engineering II - Course Goals:
1. Describe, in greater depth, the engineering disciplines at a southwestern institution.
2. Individually, or as a member of a technical team, apply knowledge of a structured engineering problem solving process, engineering fundamentals and basic engineering science concepts to create more advanced engineering criteria, discovered using a design process, that satisfy a problem of engineering interest.
3. Design processes to communicate technical information orally and visually.
4. Implement complex algorithmic solutions to engineering problems/designs using an appropriate computer tool (Excel, LABVIEW, and MATLAB) and be able to explain your rationale for your choice;
5. Synthesize your knowledge of effective and ethical membership on a technical team (i.e., teaming skills) to refine your conduct as a member of the team.
6. Exhibit a work ethic appropriate for the engineering profession.

B. Procedures

Pre- and post-engineering enculturation surveys were developed to see how students exhibit characteristics of the engineering enculturation outcomes through the engineering program on their way to becoming professional engineers. The students were surveyed with open-ended questions and their responses were dissected for dominant viewpoints. First, the entire FYE foundation course of over 3,600 students was invited through an email to participate in the study. The recruiting was also conducted via announcement on the sections’ community web pages and by instructor or one of the authors of this study visited some sections for direct appeal to students and encouraged their participation. While 284 students elected to participate in the survey, only 182 students completed their responses to the three open-ended questions and demographic questions that are the focus of this study.

C. Participants

The demographic composition of the survey participants is presented in Table 1. The dominant racial/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 Americans. The respondent pool was diverse for the study with 40.1% minorities in comparison with the overall undergraduate engineering student population at the southwestern university (34.2%).

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

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

Note. *Race/Ethnicity was categorized for domestic students only.

The students’ demographic data help distinguish answers of students of different genders and racial/ethnic groups. First-year students were not the only ones in the FYE foundation course. Some upper-level students were also in the course (15.4%). Most of these were transfer students who are required to take this course to make up for possible distinctions in pre-requisite material prior to their arrival. Some other students (Branches/Academies) were taking the course at their community colleges as joint registered at their two-year and the four-year institutions. This is designed to have them cover pre-requisite material before they enter the engineering major at the four-year institution.

D. Data Analyses

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 (Patton, 2002; Thomas, 2006). First, the two researchers independently identified the themes that emerged in the data and coded all the data based on their identified themes independently. Second, they held occasional meetings to reach a consensus on their independently identified themes. Third, they compared, discussed, and recoded until they reach a consensus on all of the coding for the themes. Finally, they finalized all the coding for the themes with labels and definitions and calculated the
frequency with which each theme appeared in students’ raw responses.

For data analyses, the number of occurrence of these common themes were totaled and plotted as a percentage of the total number of responses to a particular question. These occurrences were broken down by gender, race/ethnicity and then for the FYE students compared to the upper-level students who were in the course for various reasons (e.g., transfers needing the engineering foundation courses as pre-requisite). Table 2 displays the response rate to those questions. The smallest response rate is over 93%.

Table 2. Response Rates

<table>
<thead>
<tr>
<th>Question</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Contribution of the engineering foundation course to their engineering enculturation</td>
<td>182</td>
<td>100.0</td>
</tr>
<tr>
<td>2. Other factors that contribute to their engineering enculturation</td>
<td>173</td>
<td>95.1</td>
</tr>
<tr>
<td>3. Loss/Retention of their own culture</td>
<td>170</td>
<td>93.4</td>
</tr>
<tr>
<td>Total</td>
<td>182</td>
<td>100.0</td>
</tr>
</tbody>
</table>

III. Results and Discussions

A. Gender Differences

A.1 Contribution of the Engineering Foundation Course to Students’ Engineering Enculturation

The first survey question asked and analyzed in the study regards what the students perceive the engineering foundation course to contribute toward their developing successful knowledge, practices, and values (KPV) during the course as indicators of engineering enculturation. Dominating their answers was just acquiring the skills, knowledge, practices, values, and the ability of the course to set their foundations. The perception of the course as a “weed-out” was barely mentioned by one student.

Figure 2 shows the composition of responses with respect to the gender of the participants. The horizontal axis indicates the identified themes that most commonly emerged out of the student answers. Those themes are skills, knowledge, practices and values (KPV), the course serving as a foundation and their personal perceptions of what engineering enculturation is. The vertical axis indicates the relative frequency of occurrence of those themes. The curve for female shows the relative number of times that those common themes arose in answers normalized to the number of females answering that question. The curve for male shows the number of occurrences of those common themes normalized to the number of males. The total curve shows how many times the common themes occurred for both males and females normalized to the total number of male and female students. These are in percentages together in the same plot to overlay the results for each sub-group and the total closest to one another to make it easier to see the similarities and differences in trends. This convention is continued in other plots.
Figure 2. Contribution of engineering foundation course in developing student's successful engineering knowledge, practices, and values (KPV) during semester.

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. Their consideration of the course’s intent as foundational was low compared to other common themes, such as skills and KPV. However, female students found the course serving as providing them a foundation for engineering enculturation more than male students. Yet when it comes to which particular set of skills, female students differed greatly from their male counterparts (KPV). There is a large difference found between the genders that emerged in how female students view the importance of their own personalization of the engineering enculturation happening within them, more than male students.

Figure 3 shows the specific skills that dominated the student answers. Students listed teamwork skills, skills in general, problem-solving, communication and programming skills. The horizontal axis indicates the themes 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.
Figure 3. Contribution to the skills part of the student responses to their view of their view of the engineering foundation course’s contribution.

Typical answers for the contribution of engineering foundation course to their teamwork 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.”

“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.”

Next were skills in general that were not necessarily common to many students. The same may be said of problem-solving skills. However, most notable with problem-solving skills was how much more female students viewed their importance to their enculturation compared to their male counterparts (25% for males vs. 10% for females). One female student said: “it trains us to think like engineers”. A minority female student said:

“…good understanding of the impact of our own solutions and ability to recognize the need for the plan. More importantly, be able to use the techniques, skills, and engineering tools for practice.”
A.2 Other factors that Contribute to Students’ Engineering Enculturation

The second question asked and analyzed in the study regards what 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 several cases or emerged as a close second.

Figure 4 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 engineers, 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 FYE foundation course. Teamwork and communication were again mentioned mostly as being helpful in other courses or largely through extra-curricular engineering projects (e.g., civil engineering canoe, mechanical engineering race car, the aerospace engineering model airplane or the multi-disciplinary or interdepartmental satellite, etc.).

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 for both genders. 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:

“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.”

“More advanced engineering courses with longer projects and bigger pay-offs.”

Figure 5 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.

The most important form of interaction is 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. For example, one minority female said:

“I think classes, internships, volunteering, research, and any job opportunities would also help develop the engineering culture by individual people having different views. Additionally, the informal way engineers talk to one another outside of class will have an impact.”

Observe now the implication of the student responses to the question on what they perceived were factors outside of their classrooms impacted their engineering enculturation. Paralleling some earlier results of Copabianco (2006) and Kowtha (2008), the responses indicate that their interaction with others, in other environments (the “real” world, e.g., internships) had the greatest impact. Staying true to themselves is suggested in the responses that their personal attitudes, work ethic, ability to manage time or, more so, by some answers, their developing skills in personal time management, imply that their own internal development would be another big factor outside the classroom.

A.3 Loss/Retention of Engineering Students’ Own Culture

The third question asked and analyzed in the study regards what the students expect to lose or retain of their own culture in favor of engineering culture. Many students expected to retain many aspects of their own culture but also retain the engineering culture that they would learn.

Figure 6 shows where male and female students are almost completely in agreement in how much a student expects to “retain my own culture” and mindset, habits. For these two items, it is either lose or retain. Some want to lose some or most of their own culture in favor to attaining whatever will lead to success in engineering. Some students expected to supplement problem-solving skills or retain those learned in class in upcoming years’ classes. The same was said for expectations to gain/retain knowledge/learning abilities acquired in the first-year class. Communication and other current knowledge, practices and values were the last as far as expected to retain.

Female students were only slightly less willing to lose some habits as they undergo some engineering enculturation. Typical of these were answers like:

“I expect to lose the mindset that all failure is bad as well as the mindset that I have to do all of the work every time and for all projects. I hope to gain a better sense of confidence and, while maintaining my independence, know that I have others around me to help and to guide me.”

“I expect to retain my own sense of wonder and curiosity. I’ve always been naturally curious about learning how things work and enjoy trying to figure out how to make it work. I expect that wonder and curiosity to stay with me and to
“fuel my passion for engineering as I move forward through the enculturation process.”

Figure 6. Student responses to “What have you lost or retained about your own culture in favor of engineering culture?”

B. Differences in Responses Between White and Non-White Students

B.1 Contribution of the Engineering Foundation Course to Students’ Engineering Enculturation

Student responses to the questions did not show many differences due to race/ethnicity except in a few areas. These particular areas are examined further. The view of the foundation course hardly showed any significant difference by race/ethnicity (Fig. 7).
When it came to specific skills, Figure 8 showed that non-White students were more concerned about their programming skills’ impact on their successful engineering enculturation. Some of those concerns were about the particular programming in a specific language and not as much as understanding the algorithmic thinking, which itself was a concern for some students. Note that despite the relationship of algorithmic thinking and programming, students did not always seem to perceive that relationship. The breadth of answers include these non-White students:

“The engineering foundational courses will help me by giving me access to various uses of computer technology such as MATLAB and LabVIEW.”

“I expect the engineering foundational course to hone my engineering knowledge and it will guide me in the right direction for my thinking process when approaching a problem.”
B.2 Other Factors that Contribute to Students’ Engineering Enculturation

When it comes to other factors impacting their enculturation, Figure 9 shows some notable contrasts. White students attributed three times more factors regarding their particular characteristics (attitudes, work ethic/time management, interests, learning ability, etc.) than non-White students and how those, in-turn, would impact their enculturation. Non-White students did not attribute much to other courses and extra-curricular activities (clubs, organizations, societies, community, etc.) as White students by a wide margin (20% by White students vs. 10% for non-White students). Non-White students noted more knowledge, more other opportunities for teamwork and building communication skills elsewhere as important. For example, one non-White student said:

“Having more practice in computer knowledge and more hands on projects creating other products that are not just lego robots.”
Figure 9 also showed the consistent high value given to “interacting with others”. Figure 10 details that interaction shown in the importance given to interacting with friends, more than with peers. Non-White students emphasized this over White students by a wide margin. These interactions were also much more highly valued than interacting with engineers in the profession (e.g., via internships) or professors. For example, one White female student said:

“The extra resources available. Working with other engineering students in other aspects.”

One non-White female student said:

“Besides the foundation of our program, one very important tool to improving the engineering culture is the people around us. My fellow peers I believe our a huge part of my success here ..., listening in on what they have to say and what routine they practice, I have made some beneficial changes to my schedule.”
B.3 Loss/Retention of Engineering Students’ Own Culture

Figure 11 showed the general expectation to retain one’s own culture over engineering culture. However, non-White students valued this by 55% compared to White students at 45%. Typical student answers include this White female student saying:

“I think I will retain my excitement over the end goals. In my experience, engineers are often times more concerned with solving problems that already exist than finding new things for technology to do. I’m interested in both, but I really want to get to push the limits.”

A non-White female student said:

“Respecting others opinions is something I expect to retain in my own culture. This is because while working with a team all team members need to have input in finding a solution.”

It is fascinating that the dominant answer to the survey question on what is lost, gained or retained of one’s own culture in favor of engineering culture showed that most students seem to favor retaining their own culture. However, it was not necessarily the case for some racial/ethnic groups. For example, one Asian student said:

“I’ll be willing to give up my Chinese background if I can master the Computer language which is all in English. But once I’m able to perform professionally, the success that it bring will allows me to regain most thing I lost”
C. Differences in Responses Between First-Year and Upper-Level Students

C.1 Contribution of the Engineering Foundation Course to Students’ Engineering Enculturation

Now onto the analyses in responses of FYE students compared to upper-level students who are required to take the engineering foundation course. Figure 12 indicates that first-year and upper-level students highly value the role of acquiring skills in engineering enculturation. However, the importance of the course as contributing to building a foundation is not seen as that much by upper-level students by a wide margin. Upper-level students also seem to favor their own perceptions or understanding of how they are undergoing engineering enculturation, probably because of more years of experience in the midst of the process, than their counterparts.
Now when it comes to the particular set of skills to which the students attribute to the contribution of the engineering foundation course, Figure 13 suggests that upper-level students are not as inclined to attribute as much to the FYE foundation course as the first-year students. The shift is in the importance of programming skills, which may be due to what the upper-level students are seeing as needed in their upper-level courses.
C.2 Other Factors that Contribute to Students’ Engineering Enculturation

When it comes to what other factors outside of the course impact their enculturation, Figure 14 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 (32% for upper-level students vs. 6.8% for first-year students) 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 15 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 14. Other factors impacting development of student’s successful engineering culture (knowledge, practices, and values) during semester.
When it comes to what they might gain, lose or retain of their own culture, in favor of engineering culture, Figure 16 shows again that all students feel that they are likely to retain their own culture. Upper-level students seem less concerned about teamwork and problem-solving skills, yet these are skills with which they would have time for more practice. An upper-level student said:

“I expect to retain the idea of innate personal purpose within engineering culture. I think that most engineers maintain that they must work to impact the world as a productive force.”

And another upper-level student said:

“I’m much older and don’t feel I “lose” anything about my own culture from normal experiences.”

Yet another first-year student said:

“I plan on retaining all that I am familiar with in my culture, but to improve on it and add to it through my engineering education.”
Figure 16. Student responses to “What have you lost or retained about your own culture in favor of engineering culture?” Differentiating first-year students from upper-level students in the engineering foundation course.

IV. Conclusions

This paper presented analyses of engineering enculturation constructs in the way that diverse groups are assimilated into engineering practices. The diversity of the student pool showed a relatively large percentage of Hispanics, no doubt due to the nature of the southwestern institution, seconding the typical White male dominance in engineering.

The few areas where significant differences between the genders showed was in interacting with others. Female students valued developing problem-solving skills as important to successful engineering enculturation. Female students valued the importance of interacting with friends more than male students whereas male students valued interacting with professional engineers more.

Non-White students emphasized interacting with friends, more than peers, over White students by a wide margin. White students attributed three times more factors related to their particular characteristics (attitudes, work ethic/time management, interests, learning ability, etc.) than non-White students and how those, in-turn, would impact their enculturation. Non-White students did not attribute much to other courses and extra-curricular activities (clubs, organizations, societies, community, etc.) as White students. Non-White students were more concerned about their programming skills’ impact on their successful engineering enculturation. Some of those concerns were about the
particular programming in a specific language and not as much as understanding the algorithmic thinking, which itself was a concern for some students.

Upper-level students did not place as much value on the engineering foundation course as the first-year students but then they have taken many more other courses and are only in this course to satisfy requirements other than introduction to engineering. Upper-level students valued connections with peers and friends outside the course by a lot more than their first-year counterparts but then they would have formed more of such connections by the time that they have attained their level. These upper-level students expected to lose less of their own culture in favor of engineering culture. However, some of their responses suggest that they are incorporating engineering culture into their own.

A. Limitations and Suggestions for the Future Work

A number of African-American students did not choose to participate in the study to be able to make observations about them as Yoon et al. (2013) did in noting how Asian Americans were more likely to exhibit engineering enculturation. It would help to be able to analyze responses of specific racial/ethnic groups rather than group all minorities or non-Whites. Recruiting for these studies will need to be strengthened. For example, allowing more time for in-class participation will be more utilized but it still does not guarantee that students will devote a given amount of time to a voluntary task of filling out a survey.

The relationship of the students’ value of interacting with others, whether in or out of class or the “real world”, and their constant citing of teamwork and communication, related skills, suggest an area for further research. Combining this with more student responses and even more diversity, such that we do not have to consider all non-White students as a whole, would add further details to the analyses.

B. Significance of the Study

Most noteworthy is how much all students value acquiring skills to achieve engineering enculturation. When examining further into which particular skills, male students emerged as valuing teamwork as the one amongst the set of skills more than female students. Non-White students valued the importance of developing their skills to achieving successful engineering enculturation. When asked to identifying outside factors to engineering enculturation, most students favored friends and peers, with non-White, female and upper-level students somewhat more.

Also noteworthy in the results is the emergence of the view of teamwork and communication as important by students in almost all of their responses. Teamwork and communication skills appeared in student responses to all three questions, in various degrees. This supports an earlier study (Richard et al., 2016) that sought to quantify any correlation between teamwork and communication skills and engineering enculturation and some earlier observations. Cavenett and Rawson (2013) observed the importance of team or group work and interaction, especially group identity, and not just individual
identity, to engineering. Chen et al., (2015) made similar observations of the importance of team project work for minority students. However, while identifying as an engineer may be related to engineering enculturation, the distinction may yet be an area to incorporate into future work (e.g., Meyers et al., 2012; Kangasoja et al., 2010).

Acknowledgement

This work was conducted under the auspices of the National Science Foundation (NSF) under grant number EEC-1640521. However, any items expressed in this paper do not necessarily represent the views of NSF or its affiliates.

References


adjustment in organizations. *IEEE transactions on engineering management, 55*(1), 67-81.


