AC 2010-1814: PERCEPTIONS OF MILLENNIAL STUDENT LEARNING: THE FUTURE FACULTY PERSPECTIVE

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Perceptions of Millennial Student Learning:
The Future Faculty Perspective

Abstract

In order to promote student learning, instructors must understand who is in their classroom and how those students learn. Currently, many engineering courses are composed of "Millennial" students. This term is used by academics, university administrators, and industry leaders in the United States to describe the generation born between 1982-2002.[1] In recent years, this generation has created quite a stir among practitioners in higher education and industry. Since the seminal work of Howe and Strauss (2000), many have wondered how Millennials will change higher education and the workforce.[1,2] One limitation of Millennial research is that it fails to empirically engage the perspectives of those who teach Millennials. Thus, researchers know little about how instructors think about Millennial students and the implications that these perceptions have for teaching and learning. Concurrently, research in engineering and engineering education has focused on curricular reforms and instructional methods for preparing the Engineer of 2020.[3,4] Specifically, the learning outcomes for the Engineer of 2020 affirm the complexities of a changing workforce and need for innovative and adaptive problem-solving. Within the engineering context, there is limited research that merges these curriculum outcomes with the benefits and challenges associated with teaching the Millennial generation.

To merge these two concurrent trends in postsecondary and engineering education, our study provides a qualitative analysis of how future faculty perceive Millennial engineering students at a large research university. The engineering graduate students who participated in this study are experienced graduate student instructors and were selected based on three criteria: 1) they have a demonstrated commitment to engineering education, 2) they participate regularly in reflective conversations about teaching and learning, and 3) they are uniquely situated, in terms of age and professional status, allowing them to comment on the opportunities and challenges related to teaching Millennial undergraduates in various engineering disciplines.

This study poses the following research questions:

- What knowledge do future engineering faculty and industry leaders have about the Millennial generation?
- How--if at all--do future engineering faculty think Millennial students will affect their teaching?

To answer these questions, we have used the following methods. First, we conducted an exhaustive review of the literature on Millennial students, and identified three striking characteristics of Millennial students (i.e., their preferences for collaborating with peers, connecting with one another, and creating for social change). Second, we followed up this literature review by reporting survey and focus group data collected from the select sample of engineering graduate students. Specifically, the survey includes demographic information about the cohort including birth year, gender, race/ethnicity, and semesters of teaching experience. In addition, we asked participants in the study to reflect on their familiarity with the term

"Millennial Generation." Finally, we followed up with focus groups to explore their initial thoughts on teaching Millennial students in the context of others to determine how these ideas are extended (or amended) during the group interaction.

In this paper, we summarize how future faculty members define the Millennial generation and their perspectives on teaching Millennial engineering students technical knowledge and skills (e.g., science, math, problem solving, etc.) and profession skills (e.g., ethics and communication). We contrast these findings with the literature on "best practices" in teaching, ABET criteria, and attributes for the Engineer of 2020. Implications for teaching, learning, and future faculty development will be discussed.

Overview of Engineering Curriculum Developments

The quality of engineering education and the ability to recruit a U.S. engineering workforce has been a growing concern among engineers in university and industrial settings. In the 1990's, ABET, the engineering accreditor of postsecondary degree-granting programs, revamped the program outcomes and assessment criteria to improve quality by implementing the Engineering Criteria 2000 (EC2000).[5] Beginning in 2001, all accredited engineering programs were required to demonstrate that their graduates possess the following eleven skills (known as a-k):
- Ability to apply knowledge of mathematics, science, and engineering;
- Ability to design and conduct experiments, as well as to analyze and interpret data;
- Ability to design a system, component, or process to meet desired needs;
- Ability to function on multi-disciplinary teams;
- Ability to identify, formulate, and solve engineering problems;
- Understanding of professional and ethical responsibility;
- Ability to communicate effectively;
- Broad education necessary to understand the impact of engineering solutions in a global and societal context;
- Recognition of the need for, and an ability to engage in life-long learning;
- Knowledge of contemporary issues; and
- Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.[5]

This model reflects an outcomes assessment approach to accreditation as opposed to the former input or prescriptive model.[6] Research comparing engineering student experiences prior to EC2000 with those students who were educated after the installation of EC2000, showed that employers found the students to have comparable fundamental technical skills, while gaining professional skills needed in industry (e.g. communication, teamwork, etc.).[5] In addition to the calls for improvements in the accreditation process, the National Science Foundation expressed concerns about developing and educating the engineer of 2020.[3,4] Both calls respond to the need to recruit and retain talented students to supply the U.S. workforce. The attributes of the engineer of 2020 include: strong analytical skills, practical ingenuity; creativity; communication; business and management; leadership; high ethical standards and professionalism; dynamism, agility, resilience, flexibility; and lifelong learners.[3]

The national initiatives shaping the future of engineering education raise a number of important questions: How should engineering educators teach today's students to develop these skills?

How do these attributes prepare students for a globally competitive and rapidly-changing technical environment? How are engineering educators recruiting, retaining, and developing diverse students to maintain U.S. global competitiveness in an era where the number of engineering degrees granted to domestic students is declining? These questions are fundamental to the work of engineering educators and engineering educational researchers. At universities like the University of Michigan (U-M), recent curriculum plans have been developed to help faculty think about reshaping and revamping the curriculum to best train and develop undergraduate students for the 21st century.[7]

In an attempt to understand how to recruit and retain Millennial engineers, Chubin et al. (2008) analyzed data from the Academic Pathways Study to describe the Millennial generation's—students born between 1982-2002—knowledge of engineering prior to college, their motivation for choosing engineering, and their perceptions of their needed and gained skills.[8] Chubbin recommends, "To retain talented students in engineering programs, educators must develop innovative ways to engage students and expose them to skills and knowledge beyond the university setting" (p. 253).[8] In light of this work, engineering instructors must understand who Millennials are and their learning needs in order to design and implement innovative and engaging pedagogies.

Who are the Millennial Generation?

Millennials (also known as Gen Y, Net Gen, etc.) were born between 1982 and 2002[1,9] and account for approximately 80-100 million U.S. Americans depending upon when one defines the beginning and end of the Millennial generation.[10,11] Millennials are considered the most racially and ethnically diverse generation in the history of the United States in that one in five has a parent who is an immigrant.[1] However, research on Millennials tends to focus on the similarities within the group. In their seminal book, *Millennials Rising*, Howe and Strauss's (2000) offer seven characteristics to describe this generation based on shared historical experiences, demographic statistics, and anecdotal data (e.g. special, confident, conventional, sheltered, team-oriented, achieving, and pressured).[1]

In addition to these qualities, Millennials' technological capabilities is a prevalent theme in the Millennial generation literature.[12,13,14,15] For example, Taylor (2005) coined the term "technoliterate" to express the technological capacities of Millennials.[12] Similarly, Prensky (2001) uses the phrase "digital natives" to imply that Millennials have been enculturated into a society that is increasingly comfortable with and dependent upon digital technologies (e.g., laptops, iPods, smart phones, gaming systems, etc.).[13] As digital natives, Millennials accept technology and the rapid rate of technological change as simple facts of life. Thus, Millennials have been said to be more adept at responding to technological change and more creative in using technology.[13,16,17] While it is difficult to refute that Millennials have had a very different experience with wireless and computing technologies, instructors should not assume that all students share the same desire to learn using specific technologies, have the same access to technology throughout their lives, and are aware of the latest technological developments. [18,19]

Moreover, Millennials are described as having a desire to "multi-task." [21]Multi-tasking may be seen as positive because it can expand methods for learning and increase productivity, or it may

be seen as negative because it may promote shorter attention spans. Whichever judgment one makes, Millennial students' ease with technology and desire to multi-task have implications for teaching and learning that we must consider.

Surely, there are inherent limitations in generational theory.[11] Despite these limitations, Howe and Strauss's framework has been used by researchers across disciplines to inform approaches for motivating, supporting, and teaching Millennials.[2,9,10] Critics such as Singham (2009) argue that these characteristics over-generalize Millennial students.[20] According to Singham, "generational stereotypes are of no value for professors" (p. 4) because there are more differences within groups than between them.[20] Interestingly, Singham also claims that faculty must examine the novel ways in which student behaviors (e.g., the need for instant feedback) are manifesting among Millennials. We feel that such polarized debates are unproductive. Instead, instructors should use scholarly evidence to make informed decisions about how Millennial students are impacting their teaching and/or how their teaching must be adapted to help Millennial students meet the challenges of a changing world.

Methodology

Recall that the purpose of this study is to provide an inductive analysis of how future engineering faculty and industry leaders perceive Millennial engineering students. In particular, we address the following questions in our study:

- What knowledge do future engineering faculty and industry leaders have about the Millennial generation?
- How--if at all--do future engineering faculty think Millennial students will affect their teaching?

To address these questions, our methods of data collection sought to produce a rich body of evidence, detailing how future engineering faculty perceive Millennials and how those perceptions might shape their pedagogy. After obtaining approval from our university's institutional review board, we analyze the data using a three-step process of inductive thematic analysis.[22] We outline these methodological procedures in the sections below.

Participants

Participants in our study included ten advanced engineering graduate students, who are experienced graduate student instructors (GSIs) or teaching assistants (TA) in the College of Engineering at the University of Michigan. They serve in the engineering GSI mentor (EGSM) program, which is a highly selective program where less than 5% of the teaching assistant population are hired and trained by the Center for Research on Learning and Teaching North.[23,24,25] They receive extensive training to consult with their peers about pedagogical topics, observe classrooms, gather feedback from GSIs' students, and conduct teaching-related workshops. Their training consists of introductory TA development workshops and ongoing professional development sessions held throughout the term.[23, 25] In these sessions the EGSMs learn about topics such as learning styles, multicultural teaching and learning issues, active learning, and teaching with technology.

The 10 EGSMs in our study represent a broad disciplinary background (e.g., aerospace engineering, biomedical engineering, chemical engineering, industrial and operations engineering, and mechanical engineering) and have served in the program for an average of 2.8 semesters. All participants were born at the end of Generation X (1961-1981)[1] or at the beginning of the Millennial Generation (1982-2002)[1]. Their average age was 27 years old. Because of this, they may share characteristics commonly associated with one or both generations.

In comparison to the population of graduate student instructors in the College of Engineering, the EGSMs in our study have taught for more semesters on average and are more likely to express interest in a tenure or tenure-track faculty career (Table 1). Moreover, EGSMs are as likely to express interest in pursuing a career in industry. Survey respondents were allowed to choose more than one potential career path (Table 1).

Table 1. Comparison of Teaching Experiences and Career Aspiration between EGSMs and the Engineering GSI population.

	EGSMs (N=10)	GSIs* (N=135)
Teaching Experiences		
Average Terms Teaching as a GSI	3.4	1.8
Career Aspirations		
Academia (Lecturer)	4 (40%)	40 (30%)
Academia (Tenured or tenure-track faculty)	8 (80%)	60 (44%)
Academia (Research Scientist)	6 (60%)	39 (29%)
Business (Entrepreneur, etc.)	5 (50%)	44 (33%)
Government (Politician, Science Policy Advocate, etc.)	3 (30%)	16 (12%)
Industry (Engineer/Research Scientist)	10 (100%)	114 (84%)
Research Laboratory (Engineer/Research Scientist)	7 (70%)	67 (50%)
Other (please specify)	0 (0%)	3 (2%)

*Responses obtained from a survey sent to the 272 GSIs in the College of Engineering in Fall 2009 (~50% response rate)

Since EGSMs are advanced doctoral students (many of whom have reached candidacy), who also have in-depth training and experience related to effective college teaching, consulting with 20-30 GSIs per semester and providing pedagogical peer feedback, they are in a unique position to provide a future faculty perspective on teaching Millennials. This experience gives them the unique opportunity to reflect not only on their own teaching experiences, but also of the GSIs they have observed. EGSMs' unique position in the academy and diverse career plans (i.e., pursuing careers in academia and industry) produced useful insight about how this advanced group of soon-to-be Millennial engineering faculty think about Millennial undergraduate students and how they should be taught.

Procedures

Prior to a biweekly EGSM professional development meeting, EGSMs were sent a 15-item survey. The survey inquired about demographic information, including birth year, gender, race/ethnicity, and semesters of teaching experience. In addition, we asked participants in the study to reflect on their familiarity with the term "Millennial Generation." This survey was

intended to prompt individual reflection about who Millennials are, and served as a basis for discussing how to effectively teach Millennials. Nine of the 10 EGSMs responded to the survey.

Following the survey, two focus groups were conducted with the EGSMs at their biweekly meeting. Participants were provided with informed consent forms and divided into two focus groups. We structured the two focus groups to ensure heterogeneous disciplinary representation (i.e., aerospace engineering, biomedical engineering, chemical engineering, industrial and operations engineering, and mechanical engineering). In addition, the two female EGSMs were placed in the same group to ensure inclusion and participation. The two focus groups were audio recorded to ensure accuracy of the transcription, each lasted between 60 and 75 minutes. To further incent participation the EGSMs were provided lunch.

We made the decision to conduct focus group interviews because they provide several advantages over individual interviews. First, they allow participants to examine and share their initial thoughts on a topic (e.g., teaching Millennials) in the context of others of equal power status. In addition, focus groups promote group synergy, allowing participants to build on one another's ideas. Group synergy in focus group interviews often allows researchers to collect "a fairly large amount of data in a relatively short period of time" (p. 109).[26]

Analytic Procedures

After being transcribed verbatim, the audio recordings produced nearly 50 pages of double-spaced text. To maintain confidentiality, we used pseudonyms to identify the participants in the focus groups. Inductive thematic analysis was used to identify patterns in participants' comments, allowing us to make meaningful interpretations and connections between central themes. Our analytic procedures were carried out in three phases.

The first stage involved *open coding*. Open coding refers to the line-by-line reading of participant comments, where each comment is compared to similar comments. This stage is exploratory and reflexive rather than linear. During open coding data are sorted (and resorted) and individual participants' comments are contrasted against one another. Each author engaged in open coding independently to get a "feel" for the data, after which time we met to discuss tentative themes observed in the transcripts. This process produced an initial set of approximately 10 codes or themes (Table 2).

The second stage of our analysis involved *axial coding*.[22] According to Ezzy (2002), "the aim of axial coding is to integrate codes around the axes of central categories" (p. 91).[22] During axial coding less-central codes are integrated, distinctions within codes are elaborated, and the terms and conditions of each code are specified. We conducted our axial coding at a second meeting where we extracted representative comments from the transcripts and discussed the properties of the primary categories and synthesized related codes of meaning producing a second set of four primary themes (Table 2).

The final stage of our thematic analysis involved *selective coding*. Ezzy (2002) states that the purpose of selective coding is to identify the "central story in the analysis" (p. 93). [22] At this point, the coding scheme is contrasted with existing theory to determine what—if any—new

insight can be gained from the analysis. During this phase of our analysis we discussed how our four primary themes compared to existing research about teaching Millennials and considered their implications for preparing Millennial engineers to meet the criteria of the Engineer of 2020. These implications are discussed at length in the final section of this paper.

Table 2. Description of open coding themes organized by the topics emerging from axial coding

Defining the "Millennial Generation	Teaching Millennials
- Behaviors (e.g., use of technology, multitasking, connection with others, etc.) - Attitudes (e.g., need for instant feedback, achieving, etc.) - Birth years/age	- Engineering knowledge and skills (e.g., fundamentals versus applied, problem solving, etc.) - Teaching Millennials with technology (e.g., technology access, consequences, appropriate uses) - Teaching Millennials in general (e.g., real-life applications/open-ended problems, active engagement)
Understanding Ethics	**Developing Workplace Communication Skills**
- Ethics and generational differences - Ethics and implications for the workplace - Teaching ethics	- Rules of appropriate communications (e.g., boundaries for interactions, responsiveness, etc.) - Channels/Methods of communication - Interpersonal communication (e.g., miscommunications, perceived lack of social skills)

In the following sections we present participants' comments from the focus groups, illustrating how each of the four themes emerged from the focus groups. Following our description of the primary themes, we discuss their meaning and implications for engineering instructional practice and developing future engineering faculty.

Future Faculty Perspectives: Who are Millennials and how do we teach them?

The focus groups provided insight about how future engineering faculty and industry leaders define "Millennial students" and reveal their perceptions about how Millennial engineering students should be taught. Here we describe how four themes that emerged throughout the interviews were expressed, using verbatim comments to illustrate each theme. In brief, the four themes are related to *Defining the "Millennial Generation,*" *Teaching Millennials, Understanding Ethics, and Developing Workplace Communication Skills*. Following this descriptive report of the findings from our focus group, we examine the implications of this analysis, its limitations, and directions for future research.

Defining the "Millennial Generation"

This study asked future engineering faculty about their general knowledge of the Millennial generation. We used three questions to prompt participants' general understanding of the Millennial Generation: "What does the phrase 'Millennial Generation' mean to you?" "How do people talk about Millennials?" and, "What knowledge or experience might Millennials bring to the college classroom that differ from previous generations?" Participants defined the Millennial

generation according to the years in which they were born and/or specific technological and multitasking abilities often ascribed to Millennials.

For example, in the first focus group Adam (a pseudonym) reported, "I assumed, maybe erroneously, that Millennials would be those who were born in the new millennium—after 2000." In response to Adam's statement, Manu said, "I thought millennial generation was…a synonym for 'Generation Y'." This launched a nuanced discussion about the specific years that define the Millennial Generation, which proved frustrating for some. For example, Frank stated, "I don't know. I mean there are so many of these generations. I don't even know what "X" [and] "Y" is." To which Adam replied, "'X' ends at 1980."

In addition to revealing a mixed understanding of the years that define the Millennial Generation, participants in both groups often referred to Millennials in terms of their technological capabilities. For example, Anya stated,

> From my understanding the Millennial generation refers to people born in the 80s and early 90s and people who are about our age now, under 20 in college and basically are really technologically savvy…they know a lot, they communicate often and frequently with each other. Everything is really fast-paced. Basically, they're all over the place.

Anya's comment is interesting in that she positions herself and her colleagues as Millennials, not because of their age, per se, but because of their technological savvy. "I think we're the beginning of the Millennial, because I would say we're all technologically savvy." Another participant, Trevor, commented that Millennials' technological savvy has specific implications for course work and learning. Trevor stated,

> I think technology is definitely their strength…conventionally people have just been using e-mails, but now [Millennials] are sharing information through so many online tools, I think they have been better than what I am…in terms of assimilating information from different sources.

However, not all participants in the focus groups viewed Millennials' technological savvy and connectedness as an asset for learning. For example, Katie stated,

> I was reading today in the *Wall Street Journal* about how…now that everyone is texting are they really being productive? [The question is] can you really multitask or are you just parallel processing [information] and not doing anything too in-depth. And I think that's more likely. You can do a lot of things at once, but I can't be on Facebook while doing research.

These comments shed light on how future engineering faculty perceive the Millennial Generation in general. First, the participants in our study were uncertain about the specific years that defined generational differences. Some even admitted to looking up information about Millennials on the Internet prior to the focus group, which, they admitted, probably indicated that they were a Millennial. Second, participants in these focus groups focused largely on Millennial students' technological savvy. Finally, an underlying theme that emerged during our discussions of Millennials' facility with technology, two important consequences of technology emerged. The first consequence relates to Millennials' ability to effectively "multitask" with technology. The

second consequence relates to the ethical issues that technology raises, both in the classroom and eventually at work.

Teaching Millennial Students

To obtain a better understanding of how these advanced graduate students perceive the opportunities and challenges associated with teaching millennial students, we asked them to describe specific knowledge or skills that Millennial engineering students need to learn and the kinds of strategies that instructors could use to teach these students.

Engineering Knowledge and Skills

In general, participants described technical and professional skills that Millennial engineering students need to learn. Professional skills include ethics and communication, which we will discuss in greater detail in subsequent sections. In terms of technical information and knowledge, one focus group discussed the tension between teaching fundamental knowledge (e.g., math, fundamental sciences, etc.) and preparing students to learn particular engineering tools (e.g., mathematical and computational software programs). Adam asserted the importance of fundamental math skills, when he said, "If you cannot do fundamental principles and fundamental analysis –and you need math to do that—then anything that you design, won't have any guaranteed properties, [and it] won't have any desired things that you want." Manu agreed with this idea when he said,

> As far as the fundamentals of like what is physics, what is math, and what are core skill sets…those should be the same; however, there are more resources now that students do need to understand how to use.

Another participant, Nathan, commented on the importance of learning how to use technology when he said, engineering undergraduates "definitely need to understand computers and realize how to use [engineering] software, do error analysis, and computational analysis of the problems."

Erik agreed with Nathan when he said,

> I agree 100% that [future engineers] will need computational skills in terms of … Matlab [or Mathematica] and, of course, I'm being very general to all types of engineers. … And then I think something like a graphics program, SolidWorks or something like that, some visual thing would be very beneficial.

In addition to these computational tools, critical thinking and problem solving are also important. Manu said, "[Engineering students] have to know how to approach [a] problem correctly and they have to have the fundamental knowledge to approach that problem and then they have to use different set of tools." These comments are comparable to the way faculty members define engineering as applied science and math and as problem solving.[27]

Strategies for Teaching Millennials

With these technical engineering skills, the focus group participants described the importance of tailoring teaching to meet the needs of students in the classroom. Katie believed,

> I think you need to use different methods to teach any different type of generation. I mean, everyone's different, [but], there's a lot of commonalities between everyone in this generation and you should try to cater to that a little bit.

In particular, participants describe the value of teaching millennial students by providing students with an appropriate context for how theory relates to practice, using technology in teaching, and using active learning techniques, such as "hands-on learning."

To help motivate students and relate theory to practice, Anya said,

> I think the millennial generation needs to learn how engineering principles apply to real life. Because I think a lot of the millennial generation is very big picture … So when you try and focus on this one math problem with 8 variables and you're taking derivatives … they don't understand it. But when you say, listen, you're going to use this math problem to solve the energy crisis, it [will be more meaningful.]"

Marvin confirmed this idea by describing questions that Millennial students want answered and providing an example of how students want to learn a particular topic in calculus,

> Why am I doing this? What's the point of this? And I think putting that into context [by saying] you differentiate because then you can find the velocity … Putting that more and more into context makes it—depending on the audience— better in terms of their actual learning of material. As opposed to just saying, [use the] chain rule [to solve].

In terms of teaching with technology, it is not surprising that the focus group participants mentioned using electronic tools based on their association of technical savvy with Millennials students. Nathan said,

> You have to realize and respect the fact that these students communicate digitally, more so than they do face-to-face. And if you can, if you could provide the knowledge to them in that form they are more likely to grasp it, and at least they'll have it available to them and so they have it available for them to succeed. I think that's the biggest thing."

Erik provided more specific examples of the type of technology that can assist student learning when he said,

> I think that the kind of new technologies that we use, an example clickers or [an online course management website] or any other electronic version of having those discussions. They don't necessarily have to be in the classroom, they can be outside the classroom, and also [give] real time feedback. … The use of [the course management site] in programming classes now as far as the forums or discussions etc. help teach the class and before that wasn't necessarily something that we had when I was learning.

Participants also debated over whether the use of PowerPoint in classes was effective. Frank believed that "you have to find the right balance of what works and what [students] have been accustomed to." He felt that PowerPoint has the capability to show videos well, but cautioned that some material was better presented using the chalkboard.

To further engage students in learning, the focus group participants suggested using active learning techniques such as teaching with clickers, but they also suggested hands-on learning opportunities. Greg expressed some hopefulness that these active teaching methods may be more common in today's classes.

> We harp a lot on active learning and different fun group exercises and case study type material and things like that whereas [earlier on] we had some of that or I did when I went through undergrad, but previous generations might not have had that experience. So I think that actually we're getting better and better.

In all, these future faculty members believe that teaching millennial engineers, like previous generations, requires fundamental knowledge and problem solving skills; however, they suggest that they way in which Millennials students are taught should be altered to better motivate and educate them. Perhaps in line with their definition of Millennials, they see technology as a powerful tool in their students' education. We will explore the implications to teaching and learning in the final section of the paper.

Understanding Ethics

A critical component of engineering education is an understanding of and ability to apply principles of ethical decision-making.[3,5] Industry and technological changes complicate discussions of ethics in the workplace. However, participants in our focus groups often noted the implications that these changes have for teaching and learning.

For example Erik stated,

> Now that everything is digital there are so many resources everywhere. We can and probably do get away with borrowing, rephrasing what other people say a little bit easier…It is probably easier to do that, so I feel like it's going to be more challenging to either catch them when they do that, or to instill this sense of responsibility, self responsibility or accountability in order for them to do it themselves.

To this point Frank responded,

> So, I wonder if there is this sort of loss of thinking or loss of creativity because the information is so readily available, and you also have to think about the correctness, like as Nathan was saying, you have so much information, you don't know whether that information is correct or not.

These comments demonstrate that the availability of information on the Internet has important ethical consequences for teaching and learning. First, instructors must teach students how to become responsible consumers of information. As Manu noted, "there is a new skill you have to

teach or maybe a new ethical code you have to teach to make sure students are responsible for their learning." Second, instructors must teach students how to become responsible producers of information,[29] which involves considering the credibility of their evidence, intellectual property, and their responsibility to key audiences or stakeholders.

Other participants noted the importance of teaching ethics due to societal changes and engineers' responsibilities to society. For example, Manu said, "I think our parent's generation would probably say that ethics was something that was basically taught in the home…and that was necessary and sufficient, but now I think there's an understanding or, for whatever reason, a shift in society."

Nathan noted that other social forces such as legal liability are driving the need for ethics in engineering education. He stated,

> It used to always be engineers… you weren't taught ethics because when you got accepted to come to a university, you came from the right mind set, you were an ethical person…Part of this ethics thing is because there have been so many lawsuits in the last 15 years. Everybody is suing everybody for everything, and maybe that's part of the reason why is that companies are spending so much money on liability insurance that if they have some more ethics taught that maybe that somehow that reduces the liability…or the lawsuits.

Taken together, participants' comments about ethics reveal important insight about teaching Millennials. Many participants situated their comments within a particular historical context (e.g., in relation to "our parents," "shifts in society," or "lawsuits in the last 15 years"). Positioning ethics education in this way illustrates the changing social, economic, environmental, and political climates that future Millennial engineers will be working in.

Thus, in thinking about teaching Millennials, perhaps educators should not preoccupy themselves with changing student characteristics per se (e.g., technical savvy, special, confident, etc.). This is not to say that diverse student characteristics (i.e., social, generational, or otherwise) are not important. Rather, it calls attention to the importance of the changing knowledge, skills, and abilities that Millennials will need to succeed in their respective professions. These involve things like cross-cultural communication, effective collaboration, ethical decision-making, critical analysis of evidence, and self-directed/lifelong learning.

Developing Workplace Communication Skills

In the workplace, technical communications emerged as an important theme for our focus group participants. As Nathan said, "You have to be able to either present, verbally, visually write… now days we must teach those things." The focus group participants' workplace communication comments focused on rules for appropriate electronic communication, channels or methods of communication, and interpersonal communication or social skills.

Rules for appropriate electronic communication

With regards to email communication, Katie expressed some frustration about unprofessional emails with students in her class.

> I think that because they're so used to these instant responses they end up sending rude emails, wanting their instant response. … I don't want to have conversations over email that are not addressing who you're talking to and just like, real quick type of conversation. That's fine for an I.M. [or instant messaging] when you know the person but they end up sending rude emails in more professional situations.

Greg, who does not identify as a Millennial, corroborates this idea when he said,

> We all learned they have a template for writing a business memo, and they had a template for writing your resume. There could be a communications class where they learn a template, like, this is the way you write an email to someone you've never talked to before and this is the way you should address someone if it's a business situation. Similar to how you learn to write a memo…. We've reached the point where they almost need like, here is a stenciled outline of what your email should pertain to when you're asking someone a question and you've never met them before.

While undergraduates at this university are required to take technical communications courses, these TAs' experiences indicate that students may not always apply these skills in situations that are not associated with a particular classroom assignment.

Several participants expressed concern about the expectations that Millennial students have with the responsiveness to electronic forms of communication. Manu described it this way,

> Well, one of my worries, if you will, is the work-life boundaries shift and I think that's a challenge. There is an expectation that when someone sends you a text or e-mail or whatever that there will be a response. Almost regardless of what time it is. And so yeah there's that kind of expectation that I think is a real challenge of trying to balance that.

Similarly, Katie described the concern about the ways in which undergraduates in her classroom interact with her as a TA with regard to response times associated with email communication. The instructor describes how she adjusts her course policies to help students see the connections between professional behavior in school with the workplace.

> I have a strict email policy with my students that I will not respond to their emails over weekends. [Millennial students] are shocked that if, I will not respond at Sunday night at 6pm. … I see how they're interacting and I'm like, you can't interact this way in the work place and so I'm going to have these policies because you need to learn these skills before you go out and represent [this university]

The need to teach Millennials students how to interact in a professional environment using email and the appropriate response time for message is only one dimension of workplace communication skills suggested by the focus group participants.

Channels of Communication

Another dimension associated with technical communication is the various ways in which employers and employees communicate with one another. These channels may include written correspondence in the form reports, emails, text messages, etc. According to Nathan, "I always associate with people that grew up with the ability of communicating other than written letter and in-person, voice telephones. So that…our particular generation grew up with cell phones and laptops. I mean I had instant messaging in high school." While these experiences were not uniform across our focus group participants, some describe how the presence of "non-traditional" forms of communication may impact the workplace.

Manu, who identifies as being a Millennial, said,
> I fully expect to communicate with my peers … through different means than I do now or that I have up to this point, so for example, like texting. If I'm a manager, most likely I'm going to send text messages to you know the people I work with a lot more than is taking place now or what was taking place before. Because you know research is showing you know, this generation if you will, that's one of their preferred methods of communication. If you understand that then use it. I'm not saying that we only would communicate with text. I'm just saying that that's something that you have to integrate if you want to be able to communicate effectively with them.

While the channels of communication may vary, some described that the quality of communication may decrease with the use of nontraditional forms of workplace communication, such as texting. For instance, Nathan described it this way,
> If you think of quality of … how much of the useful thing you could put inside of the volume. You have a lot of wasted quality in a text message. You have a lot of these texts that are "k" or you know whatever. And so, it's a bunch of waste. Just like we get a whole bunch of junk e-mails or junk communication, right? So quality in terms of usefulness is probably down because of that form of communication.

Even further, there was some discussion that, while the quality of communication "in the sense of the content or the context or the usefulness of," information may decrease, the efficiency at which information is exchanged between people who understand texting may increase.

Interpersonal Communication Skills

With the variety of digital channels that Millennials are accustomed to using, some of the focus group participants expressed some concerns about how the interpersonal communication skills might suffer (or potentially clash) with the expectations of others (especially non-Millennials).

For instance, as Nathan said "real" or "face-to-face" interactions may suffer. According to Nathan, "If you are used to communicating in this digital medium, maybe you'll lose some of the ability to communicate with others in a real [face-to-face] sense." One specific example, where good social skills are paramount include interpersonal conflicts. Greg coined this process as "social problem solving."

More specifically, Anya said,
> If you disagree with someone, if you disagree with your boss, if you think that they're wrong, how do you approach that problem in a non-combative way? … I think there is a lot to be said for learning how to problem-solve in a way that includes everyone, in a way that makes your point clear and concise without being rude. I don't think students know that."

In contrast to in-person communication, conversing in digital media such as online social networks introduces an interesting challenge, as Greg said representing "voice inflection and mood" may be less apparent for some. He also said,
> Now you can have quote unquote 'social skills' and tremendous networks and experiences based on those but you still never really had to learn how to talk to people. How much of a lack of perceived social skill is just their personality or how much might be due to their reliance on these technological tools to do all of their communicating instead of learning how to read body language, and learning how to talk to people and learning how to be comfortable in those situations. I'm afraid that it might lead to more and more situations where people are going to have almost a social anxiety because they're not used to talking to people anymore. And whether or not that really comes to fruition it's a different story, but we'll see what happens.

Katie described the tension as a need to reinforce respectful approaches to interacting with different people as follows:
> I think that when there is no standard of how you interact in situations you need to go about it as the most respectful way possible and then you're told about the exceptions type of thing. And that's how you just interact with people. So those are other skills that need to be learned.

More specifically, Anya expressed concerns about when it is appropriate to respond to text messages when having in-person conversations, when she said,
> But if we were trying to have a serious conversation … I think it would be rude of me to answer my email and check my text messages as equally as I think it would be rude for them to do them same. You're having a conversation.

These comments highlight how norms of behavior may vary generationally and being able to communicate the proper workplace expectations may need to be defined.

In all, workplace communications in-person and electronic are perceived to be essential professional skills for Millennial engineering students. Given the importance of this learning outcome, courses in technical communications and opportunities for students to

work in diverse teams remain valuable elements to the curriculum so that students can develop this professional skill. Given this, have engineering educators fully considered the technical communications curriculum to address traditional and more novel forms of communication in the workplace? Are there ways for the professional skills to be better woven into the curriculum and teaching practices as suggested by Sheppard (2009)?[28]

Implications for Teaching, Learning, and Future Faculty Development

This qualitative analysis of the perspectives of future engineering faculty and industry leaders provides us with useful insights about teaching today's students for their future careers as engineers. Their comments focused on *Defining the "Millennial Generation," Teaching Millennials, Understanding Ethics, and Developing Workplace Communication Skills.*

Like other researchers, the focus group participants define Millennials not only by their birth years, but also by particular attributes such as their perceived preference for using technology and multitasking. While these attributes were described in both positive and negative terms, it presents a unique opportunity for faculty to think about ways to harness students' potential interest and familiarity with technology in a way that can assist their learning. To provide a couple of examples, faculty at the University of Michigan have leveraged Millennial students' affinity for technology by having first year students develop a web-based chemistry textbook and allowing more advanced students to generate class notes using a wiki and post test questions online.[29] Since teaching with technology is not "a silver bullet that can promote learning by itself," [30] faculty developers recommend that instructors consider students' previous experiences with technology, their access to technology, and their learning styles, when integrating technology into the classroom. [31]

When defining the Millennial generation, one characteristic that was not mentioned in the focus groups is the racial and ethnic diversity within the generation. While we did not specifically ask participants to describe the diversity from within the group, recognizing difference (not just commonalities) is important in teaching students effectively. Respecting diverse talents and ways of learning is considered one of the seven principles for good practice in undergraduate education.[32] Recognizing diversity and teaching to the needs of all students has an interesting implication for engineering education and workplace interactions. With the national calls to recruit and retain a diverse pool of engineers, the racial and ethnic diversity within the Millennial generation presents a great opportunity to address the decline in engineering graduates when college classrooms supports the diversity within the student population. In addition to recruiting diverse students, preparing students for diversity and cross-cultural interactions is necessary for the global nature of engineering industry.[34] Engineering faculty must show students how principles of engineering affect people in cultural communities that are different from their own, and engage students in designing solutions for culturally complex problems. For example, one U-M faculty member lead a team of students overseas to observe the medical needs at a teaching hospital and complete a service learning project.[29]

The professional and technical skills that these future faculty members identify as being important overlap to some degree with the ABET criterion 3 (Table 3) and the attributes of Engineer of 2020 (Table 3). In particular, the skills needed for ethical decision-making and

communication, which are both elements of ABET and the Engineer of 2020, were voiced in both focus groups. This suggests that the increased awareness in the engineering curriculum on these professional skills are accepted and valued by these advanced doctoral students.

The participants also highlighted the importance of relating the theory of engineering to the "real world" and identifying the "big picture" to help students learn. These ideas begin to introduce the notion of incorporating the "global and societal context" and "knowledge of contemporary issues" in engineering education. In order to make connections from their non-engineering courses and technical content, faculty and graduate teaching assistants should consider encouraging Millennials to bring their knowledge and experiences from their non-engineering classes and life experiences to think about how their engineering solutions and processes impact society at large. This approach can enhance student motivation and their understanding of the course material.

In terms of technical content, fundamental knowledge of math and science were considered important; however, it is interesting to note that there was no mention of the need for future Millennial engineers to (1) design and conduct experiments, as well as to analyze and interpret data or (2) design a system, component, or process to meet desired needs (Table 3). Although these skills were not mentioned, it does not mean that they are valued less by the participants. It may only mean that when thinking about undergraduate student experiences, the most pressing skills were those previously mentioned.

There were several attributes of the Engineer of 2020 that were not identified, such as skills in creativity, business and management, leadership, dynamism and resilience, and life-long learning (Table 3). Given that we are working with a small pool of students, there is a possibility that other advanced graduate students would have mentioned some of these characteristics. When reflecting on the skills and attributes that were not mentioned during this study, it is important to consider the fact that these advanced doctoral students have had more classroom teaching experience when compared to their counterparts and they potentially have had more opportunities to reflect on teaching and learning on a regular basis through the biweekly meetings that are a part of the EGSMs' professional development. We recognize that the participants in the study are a highly selective group from a research university and that member checking and/or additional research is needed on this topic, increasing the trustworthiness of our findings.

Regardless, engineering educators must do more to encourage all graduate student instructors and those graduate students who might consider careers in academia, the opportunity to learn about "best practices" in teaching, to apply the skills and attributes of the Engineer of 2020 in their own teaching, and reflect on ways to assess their effectiveness as instructors to achieve these goals. How are future faculty being prepared to teach these issues? What changes to the graduate student curriculum or the professional development practices should engineering administrators consider? Programs like the Engineering Graduate Student Instructor Mentor (EGSM) program at the University of Michigan provide only a small group of advanced engineering graduate students the opportunity to develop their awareness about essential teaching and curricular developments. We recommend faculty and administrators expand the education and development of graduate students to include not only research aspects associated

with academic careers, but also include faculty and peer mentoring on the teaching as well. While this idea is not novel, finding viable approaches to initiate this effort is still needed. One approach is already being implemented at Virginia Tech University, through the Graduate Teaching Fellows program,[33] where over the course of three years graduate students receive greater teaching responsibilities, while being mentored by a faculty advisor. Creating a culture where reflective teaching practices are valued creates an opportunity to improve the learning experiences of students and the teaching experiences of current and future faculty.

This paper provides insights into the perceptions of future faculty and industry leaders by analyzing their comments about teaching Millennial engineering students. The voices from this cohort of advanced doctoral offer a window into the teaching environment at a research university, but to learn more about how instructors think about teaching Millennial students, future work must focus on advanced doctoral students and faculty within this university and beyond our institutional context. At present engineering educators have 10 years to meet the goals set forth for educating the engineer of 2020. If we are to achieve these goals, we must learn more about Millennial students, how they learn, what they need to learn, and what instructional practices are most effective for teaching them.

Table 3. Engineering skills based on ABET Criterion 3 in comparison with the future faculty perspective

ABET Criterion 3	Future Faculty Perspective
• Knowledge of mathematics, science, and engineering	• Fundamental knowledge (e.g., math, fundamental sciences, etc.)
• Design and conduct experiments, as well as to analyze and interpret data	•
• Design a system, component, or process to meet desired needs	•
• Function on multi-disciplinary teams	• Interpersonal skills (i.e. "social problem solving")
• Identify, formulate, and solve engineering problems	• Problem solving
• Understanding of professional and ethical responsibility	• Ethical decision making
• Communicate effectively	• Technical communications
• Broad education necessary to understand the impact of engineering solutions in a global and societal context	•
• Recognition of the need for, and an ability to engage in life-long learning	•
• Knowledge of contemporary issues	•
• Use of techniques, skills, and modern engineering tools necessary for engineering practice.	• Knowledge of engineering tools (e.g. mathematical and computational software programs)

Table 4. Engineering skills based on the attributes of the Engineer of 2020 in comparison with the future faculty perspective

Attributes of the Engineer of 2020	Future Faculty Perspective
• Strong analytical skills	• Problem solving
• Practical ingenuity	• Problem solving
• Creativity	•
• Communication	• Technical communications
	• Interpersonal skills (i.e. "social problem solving")
• Business and management	•
• Leadership	•
• High ethical standards and Professionalism	• Ethical decision making
• Dynamism, agility, resilience, flexibility	•
• Lifelong learners	•
	• Fundamental knowledge (e.g., math, fundamental sciences, etc.)
	• Knowledge of particular engineering tools (e.g. mathematical and computational software programs)

Acknowledgements

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