2006-1503: EXCELLENCE IN ENGINEERING EDUCATION AND EDUCATIONAL TECHNOLOGY: VIEWS OF UNDERGRADUATE ENGINEERING STUDENTS

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Excellence in Engineering Education and Educational Technology: Views of Undergraduate Engineering Students

Abstract

During the 1990's and continuing today there has been an increased attention to understand the issues that may affect the quality of engineering education. According to the National Academy of Engineering [1] and programs such as the Accreditation Board for Engineering and Technology (ABET), many universities around the world have been making major efforts to recognize the challenges faced by engineering educational programs and making changes to achieve "Excellence in Engineering Education". The purpose of the study reported in this paper is to understand the views and perceptions of engineering undergraduate students on engineering education in general and educational technology in particular. The method of content analysis was used to analyze the language used by engineering undergraduate students and extract the underlying common factors or perceived characteristics of excellence in engineering education. These common factors were then used to identify the similarities and differences in views between engineering students and educational researchers by comparing our observations with what has been reported in the literature. Twenty-two undergraduate engineering students (7 females and 15 males) participated voluntarily in this study to answer four individual questions about (1) excellence in engineering education, (2) educational technology, (3) the student's role in the engineering college, and (4) the professor's role in the engineering college. The participants were instructed to write 10 words or phrases that come to their mind when they think about each of the questions and rank their answers in the order of importance. Following the individual questions, ten questions were discussed in a focus group. The results of the study showed that when it comes to evaluation of education and teaching methods, students would like to see more opportunities to give input in the system and be more involved as part of the creation in all levels and steps. Current literature on Excellence in Engineering Education stresses the importance of skills and knowledge but leaves out two aspects stressed by the student participants: (1) the technology component and (2) building of relationships and a community of learning. The participants in this study described or characterized excellence in engineering education as: clear, complex, comprehensive, detailed, diverse, efficient, interactive, international, multidisciplinary, personalized, precise, scientific, specialized, and stimulating. The implications of the research results on excellence in engineering education are discussed.

Introduction

Excellence in Engineering Education

During the 1990's and continuing today there has been a great movement towards understanding the issues that may affect the quality of engineering education. According to the National Academy of Engineering and programs such as the Accreditation Board for Engineering and Technology (ABET), many universities around the world have been making major efforts to recognize the challenges faced by engineering educational programs and make changes to achieve what many are calling "Excellence in Engineering Education". As one example of the programs developed recently, in 2002, the National Academy of Engineering launched the Center for the Advancement of Scholarship on Engineering Education (CASEE) [1]. Its purpose is

to understand at a deeper level what should be taught in engineering and how to teach the students, by recognizing how they learn. Through its research and activities, CASEE has defined specific and measurable outcomes to challenge itself and the engineering community to achieve its goal of excellence in engineering education by defining excellence of engineering education in terms of its effectiveness, engagement and efficiency.

Along with institutional goals as standards of excellence, research in engineering education shows that an integral part of the process is providing the undergraduates with opportunities to develop individual characteristics that will positively impact the students' future career. Rugarcia et al.[2] state that an integral part of the engineer profile is the development of three main components: knowledge, skills, and attitudes that dictate the goals toward which students' skills and knowledge will be directed. From the perspective of faculty, Fromm [3] defines a detailed list of characteristics which future engineering graduates should possess to become leaders of the profession, including a strong foundation in basic sciences, math and engineering fundamentals, the capacity to apply these fundamentals to a variety of problems, among others.

The Millennium Project [4] at the University of Michigan is a research laboratory designed for the study of the future of the American universities. The mission of this project is to "provide an environment in which creative students and faculty can join with colleagues from beyond the campus to develop and test new paradigms of the university". The Millennium Project proposes some key characteristics of education in a society of learning, including being learner-centered, affordable, provide for lifelong learning, a seamless web, interactive and collaborative, asynchronous and ubiquitous, diverse, intelligent and adaptive. The Millennium Project states that in the process of transforming the university a balance should be achieved: among missions (teaching, research, service), among disciplines (liberal education, academic disciplines, professions), among undergraduate vs. graduate vs. professional education (e.g. educations vs. training), among sciences vs. humanities, and among life sciences vs. everything else.

Although the views proposed by educational researchers [1, 2, 3, 4, 5] are very important, it is equally important to ask: Are these views in agreement with undergraduate engineering students' perception of what is considered excellence in engineering education? This is the first research question addressed in the present study.

Educational Technology

In general, technology is defined as a collection of processes, devices, capabilities and the knowledge that accompanies them[6]. Education technology in particular, uses multimedia technology or audiovisuals as a tool to enhance the teaching and learning process [6]. This definition presents the physical science concept which views the various media as aids to instruction and tends to focus on the effects of devices and procedures, rather than the differences of individual learners[7]. Another definition of educational/instructional technology is the one developed by the Commission on Instructional Technology [8] in 1970, where instructional technology is defined as a systematic way of designing, carrying out and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication, and employing a combination of human and nonhuman resources to bring about more effective instruction. This definition brings the aspect of a behavioral

science, which does not necessarily imply the use of machines, but depends on methods of behavioral science such as psychology, anthropology, and sociology among others. Moreover, this behavioral science concept of educational technology includes the application of engineering research and development in the area of human factors engineering [7].

Considering these two major perspectives of defining and evaluating educational technology, it is important to ask: Are students' perception of educational technology similar to the definition of physical or behavioral science? What are the students' perspective on educational technology; how it is defined by them and how their views on technology might impact the understanding and use of this technology in the classroom? This is the second research question addressed in the present study.

The purpose of this study is to address the two questions raised above and to understand the views and perceptions of engineering undergraduate students on excellence in engineering education in general and educational technology in particular. The method of content analysis was used to understand the language used by engineering undergraduate students and extract the underlying common factors or perceived characteristics of engineering education; we further identified the similarities and differences in views on teaching engineering between engineering students and educational researchers by comparing our observations with what has been reported in the literature.

Participants

Twenty-two University of Michigan undergraduate engineering students (7 females and 15 males) participated voluntarily in this study. Each participant attended one of four 1-hour focus groups with 3 to 8 participants per group. One participant was interviewed individually. Each participant received a monetary compensation of $10.00 for their time.

Methods

The participants were greeted individually and asked to read and sign a consent form if they agreed to it. The participants were first asked to answer four individual "brainstorming" questions, one question at a time. They were asked to write on blank sheets of paper 10 words or phrases that came to their mind when they think about or hear a specific phrase. The phrases were: (1) excellence in engineering education, (2) educational technology, (3) student's role within the engineering college, and (4) the professor's role in the engineering college. The participants had 3 minutes to write down their responses for each phrase individually, and then hand back the sheets. Only for the phrase of "excellence in engineering education," the participants were asked to rank all the words and phrases they wrote according to what they felt were more important for them. After answering questions on the four phrases, participants were asked to participate in a focus group discussion on ten questions, which were asked by the experimenter and the responses were audio taped for transcription purposes.

Content analysis technique was used to analyze the data. It is a research technique for analyzing text data and making inferences from data to their context [9]. Liu [10, 11] applies content analysis within the context of engineering aesthetics, as a procedure to analyze selected texts with the aim

of obtaining useful insights into a research question and make inferences about their substantive problems. In this study, keyword frequency count is the content analysis index used to summarize the data. The results are presented below using two types of word frequency count: main keywords and most repeated words or recording units. Main keywords are words extracted from each participant's responses and used to summarize and group the answers into meaningful categories. Recording units are defined as nouns, verbs or adjectives that were written by the participants when answering each question. The data are summarized by showing the number of occurrences of keywords and recording units for the individual questions and the focus group discussion.

Results

Individual Brainstorming Questions

Keyword frequency values are shown below, for each of the four individual questions. The number shown next to a keyword represents the number of times that the specific keyword was recorded in the collected data. If a keyword is not accompanied by a numerical value, then that keyword was not repeated among the different participants and it only appeared once in the text.

Keyword frequency count

(1) Excellence in Engineering Education

This question generated a total of 189 words or phrases among the 22 participants, which were grouped into 19 major keyword categories as the following: characteristics or definitions of excellence (n=29), personal and professional skills (n=27), individual or personal characteristics (n=56), resources (n=22), professor characteristics (n=14), general examples of excellence (n=14), need for examples or application (n=10), hard work (n=9), knowledge (n=9), community (n=8), competition (n=6), hands-on (n=5), cost (n=3), degree (n=2), grades (n=2), pressure (n=2), accreditation and advising. Each participant ranked their responses for this individual question. Table 1 shows the responses ranked as number 1 by one or more of the participants, when describing what is more important in excellence in engineering education.

From the participants' responses, a collection of characteristics could be extracted to define excellence in engineering education, independent of gender or perceived importance. The participants of this study defined or characterized excellence in engineering education as: clear, complex, comprehensive, detailed, diverse, efficient, interactive, international, multidisciplinary, personalized, precise, scientific, specialized, and stimulating.

Table 1. Summary of the top ranked responses for the "excellence in engineering education" question and their related keyword category

Participant Responses	Keyword Category	Only Males	Both Males and Females	Only Females
Personalized instruction	Characteristics of excellence	X		
Excellence in people/students and peers	Community		X	
Student-teacher ratios	Community		X	
Money	Cost	X		
Degree/diploma and obtaining an engineering education	Degree	X		
Hard work and effort	Hard work	X		
Creativity, honesty, and interested students	Individual or personal characteristics		X	
Motivation and willingness to learn/teach	Individual or personal characteristics		X	
Oriented to improving current knowledge	Knowledge	X		
Real life applications	Need for examples or application		X	
Problem solving, establishing contacts, responsibility, doing well in classes and career beyond formal schooling	Personal/professional skills		X	
Good and responsible professors	Professor characteristics		X	
Up-to-date learning	Resources			X

(2) Educational Technology

What came to mind when participants thought about educational technology? The participants generated a total of 158 words or phrases that could be grouped into eight major keyword categories: general characteristics of educational technology (n=55), tools (n=43), specific examples of educational technology (n=22), internet (n=18), software (n=13), research (n=3), complaints (n=2), and internships (n=2). The general characteristics category includes all words and phrases that students used to define technology. The participants described technology as advanced, different from lecture, engaging, hands-on, providing independence, interactive, could be used as help, increasing and facilitating knowledge, enhancing level of understanding, being up-to-date and varied. Table 2 shows the responses for the general characteristics, examples, internet, and tool keyword categories from the two gender groups. These categories are the ones which had 15 or more responses associated to them. The "both males and females" column summarizes the keywords mentioned by both genders.

Table 2. Summary of keyword responses for the "educational technology" question, different categories grouped by gender.

Categories	Only males	Both males and females	Only females
General characteristics	advanced, applications, specific to career, enhance communication anything different from lecture, engaging, interactive, varied, providing independence, increasing knowledge, unique, speeding the learning process and the user's problem solving skills, and supplementing classroom discussions	Hands-on, used to help or aide in the process of learning, gives exposure to real-life situations, related to equipment used for the purpose of teaching and learning, used to increase understanding and being up-to-date.	used in the workplace, helps in learning for the future, a method of teaching, a resource for learning.
examples	creative learning, used for scientific data, learning and problem solving	used in laboratories and courses, and as resources for doing homework	used to get feedback, play games and read professional magazines
internet	used for class websites or resources and providing new possibilities for studying the field	technology used in distance learning and as part of course tools	chatting for discussion purposes, scheduling classes
tools	specific names of instruments used and tools such as projectors and meters used in laboratories	calculators and computers, use of video, programming software and course oriented software programs, such as Power Point	

(3) Student's role

The participants were asked to write down what they thought was their role within the school. This question generated a list of 124 words or phrases, which can be described by 20 general key words. According to the participants their role within the school is to be or do certain things which are referred to as self characteristics (n=30), to learn (n=18), prepare for the future (n=11), be a student (n=10), to mentor others (n=10), contribute (n=7), develop skills (n=6), represent their race or college (n=6), earn a degree (n=5), participate in extracurricular activities (n=3), make friends (n=3), pay tuition (n=3), have no impact at all (n=3), compete (n=2), network (n=2), experience college, maintain good grades, do research, and make good use of resources. Self-characteristic was the keyword used to group all the words or phrases that the participants used to describe themselves within their role, for example: customer, consumer, critic, teacher, writer, client, colleague, collaborator, use resources, gain respect, worker, and employee.

Table 3 shows the keywords that males and females used to describe their role in the school and similarities between the responses.

Table 3. Summary of keyword responses for student's role in school, grouped by gender.

Only Males	Both males and females	Females
competition, experience the college life, pay tuition, represent the college, be a researcher, consumer, become educated and better rounded, gain prestige, teach, and write.	contribute for the future, complete a degree, participate in extracurricular activities, make friends, prepare for the future, learn, mentor others, be a student, develop leadership skills, evaluate teachers, and gain respect	a critic, maintain good grades, interact with professors, work, generate ideas, and develop independence and skills for the future

(4) Professor's role

For this question a list of 136 words or phrases was generated by the participants. There were a total of 24 keywords identified from the list. These keywords are related to characteristics of the professors and their role in the college. These are the major keywords: personal characteristics (n=18), teach (n=15), help (n=15), work in research (n=10), mentor (n=9), encourage (n=6), be a model/inspiration (n=6), motivate (n=6), facilitate (n=5), comments from students experience (n=4), learn (n=4), educate (n=3), enforce (n=3), explain (n=3), prepare (n=3), develop personal relationships (n=3), create tests/home works (n=3), understand (n=3), grade (n=2), share information/knowledge (n=2), available (n=2), contribute (n=2), be up-to-date with real world and technology (n=2).

Compared to the other individual questions, where the participants had answers in common, the responses for the professor's role were different for males and females. Male participants mentioned characteristics of professors that included respect, willingness to teach, create a positive atmosphere and have a balance between research and teaching. Male participants wrote that the professor's role was to contribute to general knowledge and betterment of society, educate students, be the enforcer of the honor code and university principles, increase and advance student's level of understanding, prepare students for real world and employment, create good assignments and test, and set the class grade curve. The characteristics written by females suggest the role of professors in the college is to challenge students, collaborate with other professors, instruct, observe, lead, show support and provide students with opportunities for success. Female participants also mentioned that professors needed to be up-to-date with real-world and technology.

Recording unit frequency count

Table 4 shows the 14 most common words (recording units) written for each of the four individual brainstorming question.

Table 4. Frequency counts of common recording units for the individual questions summarized by keywords.

Categories	Excellence	N	Technology	N	Student's role	N	Professor's role	N
User	students	12	students	7	students	19	students	62
Needs	professors and good professors	11			help	6	help	14
					use	5		
					develop	4		
Resources	technology	7	technology	10	tools	4	professors	7
			software	8	meter	4		
			resources	8	websites	3	classroom	8
			programs	8	video	3		
			on-line	8	class	6	material	7
			power point	6	University of Michigan	5		
characteristics	excellence	6	work	6	experience	8	best	6
	competitive	5			contribute	7		
	creativity	5						
	hard work	6			friends	5	encourage	6
	good	5			make	5		
	newest	5						
Education	learning	8	teaching	7	learn	14	teach	12
	engineering	8			school	8	research	12
	education	5	understanding	4	education	7	knowledge	9
	hands-on	5			engineering	6	real world	8
	real world	5					learning	6

Analysis of Focus Group Discussion

For the focus group discussion, keyword frequency counts were used for the analysis of results. The numbers that accompany the keywords represent the number of times a different idea was brought up by any of the group members. For the analysis, if one participant brings a new idea and other group members assented then it is counted as one; but if one idea is brought up and another member specifically repeated the statement and added other new thoughts or a different perspective then the idea will appear in the analysis as repeated twice.

During the focus group activity the participants answered 10 questions that were based on topics found in the literature [2, 12, 13, 14]. Each sentence spoken by the participants was considered a recordable unit. To summarize the oral discussion a keyword was extracted from each recordable unit. The 10 general questions discussed in the focus group discussion were the following: (1)types of interactions between students and professors, (2)methods used to present information, and how would students like information to be presented, (3)what is the task of

students in the classroom and what would students like to do in the classroom, (4)what are the current challenges in the teaching environment, (5)what are the goals of teaching engineering and what types of skills and attitudes do students need to learn, (6)student experiences with alternative teaching methods, (7)what do students feel are teaching methods that work in the classroom, (8)how can a professor make students feel comfortable in the classroom, (9)how do professors learn, and (10)what is the students opinion on course evaluations. In the following we focus on the main findings from three of the questions.

(1) Methods used to present information and how would students like information to be presented?

The participants mentioned the following as common methods used to present information in the classroom: board (n=10), power point (n=5), overhead (n=4), computer (n=2), lectures (n=2), transparencies (n=2), websites, examples/applications and handouts (n=1). Students also said that they would like information to be presented through examples (n=2), stories, websites, notes, any form of visual display, handouts, and use group work to write papers and do oral presentations. There were also comments on the methods used in the classroom, for example students mentioned the following:

- "sometimes the class is too fast",
- the methods used in the classroom are "highly dependent on the subject" (all methods are not useful for all subject matters),
- "sometimes it is better if there are no handouts".

With the idea of using power point in the classroom there were multiple, even opposing ideas. For example participants said that power point "appeals to only one type of learner, is hard to read and makes professors skip steps when explaining". On the other hand, participants also mentioned that it is much better when the presentations are made available on-line; the students believed that this option saved time. It is not clear from the answers whether the time savings are reflected in the classroom, whether it contributes by increasing the total amount of materials covered or by saving student time spent writing.

(2) What are the goals of teaching engineering and the types of skills and attitudes that need to be learned?

The participants reported that one of the main goals of teaching engineering was to develop a basic knowledge (n=4) and that there was a conflict between knowledge and grades (n=2). One student compared the goal of engineering to the process of checking boxes; being prepared for graduate school and the real world, and as being "exposed" by participating in internships and cooperative education programs (Co-op). Participants also mentioned that engineering is flexible; you are taught to integrate and understand theory by taking specific courses and taught or helped to develop skills. From the participants' perspective, developing skills is one of the important goals of teaching engineering. The most common skill mentioned was critical thinking (n=3) and problem solving (n=3), followed by creativity (n=2), organization (n=2) and teamwork (n=2). Other skills were also mentioned; such as communication, discipline, responsibility, interpersonal relations, time management and writing skills. As part of the goals of teaching engineering, the literature suggests[2] that there is an attitude that is taught along with skills. The participants of this study did not seemed to think that teaching a certain attitude is part of the goals of teaching engineering (n=2), but one participant mentioned that creating a higher standard was related to the engineering attitude.

(3) What are teaching methods that work in the classroom?

Participants expressed that providing examples/application (n=7), clear objectives (n=3), presenting information in both concrete and abstract ways (n=3), and recaps (n=3) of information taught at the beginning or end of class are methods that work. Participants said that they valued when professors were organized (n=2), when they ask for questions at beginning of the lecture (n=2), and use interactive methods that break the monotony (n=2). According to the participants, some of the methods that could be regarded as interactive are working in groups (n=2), having in class demonstrations, experiments, using internet or any type of work that is hands-on. With regards to previous experiences, students like when professors provide handouts, acknowledge things are difficult and simplify the material, "feel the audience" to see if students are following the lecture, and provide students with "time to soak" or time to let the new material just presented be absorbed. In one of the focus groups a student mentioned that it will work for him if he is given more time to be self-directed and another student mentioned that power point sometimes made lectures "dull".

Researcher views on Engineering Education compared to our study results

Table 5 shows a comparison of the views of educational researchers, projects and programs with the results obtained from this study. Words in **bold** highlight the similarities between study results and researcher views. Only those common words were highlighted in the text. A detailed study of the different perspectives shows that there are many similarities between them but the language used varies, thus allowing the findings to be interpreted in many ways. For example, the participants in the study described excellence in engineering education as multidisciplinary; other perspectives describe excellence as being interdisciplinary [3], collaborative [4], and converging with other relevant non-engineering disciplines [1].

Table 5. Different perspectives on excellence in engineering education.

Study Participants—Excellence in Engineering Education	Fromm [3]—faculty perspective on student characteristics	The Millenium Project [4]—characteristics of education	NAE [1]—goals to achieve excellence in engineering education
• clear • complex • comprehensive • **costs** • **creative** • detailed • **diverse** • **efficient** • **interactive** • **interested** and **motivated** students • international • **multidisciplinary** • personalized • precise • scientific • specialized • stimulating	• advance knowledge of selected professional-level technologies • a historical and societal perspective of the impact of technology • a sense of corporate and business basics • capacity to apply these fundamentals to a variety of problems • **creative** • culture for life-long learning • **enthusiasm** for learning • intellectual spirit • knowledge and experience in experimental methods • knowledge and skills in the fundamentals of engineering practice • social, ethical, political and human responsibility • strong foundation in basic sciences, math and engineering fundamentals • strong oral and written communication skills • unifying and **interdisciplinary** broad view	• adaptive • **affordable** • asynchronous • collaborative • **diverse** • intelligent • **interactive** • learner centered • provides for lifelong learning • a seamless web • ubiquitous	• convergence with other relevant non-engineering disciplines • course integration within programs • depth-of-knowledge • **diversity** • effective instruction • **efficient** instruction • engaged instruction • ethical awareness • flexible connectivity across programs and institutions • professional discernment • provides professional and personal satisfaction • reduced attrition • reduction in **costs** • sensitivity to society impacts

Discussion

Individual Brainstorming Questions

As discussed earlier in this paper, research literature on excellence in engineering education stresses the importance of knowledge and skills [1, 2, 3, 5, 15]. It also includes institutional outcomes such as more engagement in instruction and learning, increase of diversity with respect to underrepresented groups, ethical awareness and sensitivity to society impacts, professional and personal satisfaction with the value of having studied engineering, increase retention rates, flexible programs that foster connectivity across programs and institutions, and reduction in costs [1].

Undergraduate students that participated in this study reflected in their answers all of the ideas proposed in the literature. However, the participants pointed out some ideas not reflected in the literature, including for example, the quality of the people/educational community, and the desire for more personalized instruction by decreasing student teacher ratios. This last point conflicts with general trends in education, which had increased the number of students that are enrolled in

classes. In 1990 the engineering coalition of schools for excellence in education and leaderships was established, with the purpose of renewing undergraduate engineering education and its infrastructure [16]. This program is interested in diversity, the curriculum and informal education but does not considers the learning community, materials and technology which are some of the aspects that the participants of this study mentioned as relevant (ECSEL) [17]. The ABET criteria of accrediting engineering programs is one of the documents that most of the universities around the country use as their standard. What do the ABET criteria consider being important quality aspects in the engineering programs? First, the criteria include a measure to assure *quality of engineering education*; second, the criteria state that *quality and performance of students* is an important consideration in the evaluation of an engineering program; third, the institutional support and financial resources needs to be adequate to assure the quality and continuity on the engineering program. Overall, the criteria do not explicitly consider the technology, community and the "quality" of instructors as factors important in engineering education. Many requirements and descriptors are used to define the desired characteristics of instructors but the word quality is not mentioned in the criteria to refer to instructors or professors.

With the changing nature of the need for higher education, Duderstadt [15] proposes that "both young, digital-media savvy students and adult learners will likely demand a major shift in educational methods, away from passive classroom courses packaged into well-defined programs and toward interactive, collaborative learning experiences, provided when and where the student needs the knowledge and skills…as the student is evolving into an active learner and eventually a demanding consumer of educational services." The data collected in this study from the students perspective clearly reflects that students are demanding and they know what they want and need, and are ready to communicate their ideas if they are given the opportunity.

There seemed to be a trend across all the individual questions. Among three of four questions, the word that had the most occurrence was "students" and in the educational technology question it was the seventh word that occurred the most often. This suggests that in some way excellence in engineering education and the professor's role is revolving around students. In the same way, participants used the word "students" to describe themselves, they too used the word "students" when asked about what comes to mind when they think about educational technology. From the human factors standpoint of honoring the user, it is clear that there seems to be a cry from the user population or the participants in this study to say they are very important by constantly repeating the word "students". This point is evident in student centered teaching/learning approaches [18].

Earlier we stated a question on the participants' perceptions of educational technology and how their answers reflected the concepts of behavioral or physical science. For the most part the participants' answers leaned towards the physical side of the equation with most of the answers being either physical examples of technology or ways in which it is used. The answers given by the participants reflect a general misconception of what is educational technology, which is not only multimedia and audiovisuals but in itself it is a process of teaching and learning. In an attempt to understand how undergraduate students define excellence in engineering education, educational technology, student's role and professor's role, the answers to each individual question were summarized and sub-categorized by gender. The results show that not only the general perceptions are important but that there are gender differences on how these individual

questions are defined and perceived. Further study of this issue with a larger sample and a larger number of females would give us more insight into gender differences and perceptions of excellence.

Group Discussion

Methods used to present information in the classroom

From the methods used to present information in the classroom, the use of the board seemed to be most common, followed by the use of power point slides. When the participants had the opportunity to share how they would like information to be presented they still mentioned the board, but in this case they said that they wanted to see progression of ideas and see the professor write down all the steps. With relation to what works in the classroom, in four out of the five focus groups, examples and or applications was the most common response. Other things that work in the classroom are clear objectives, a balance between concrete and abstract information and recapitulation or summary of the information presented either during the current lecture class or the material from the previous lecture. According to Felder et al. [12] instructors need to establish relevance of course material and teach inductively by relating the material introduced in class to things students already know. This point shows that the literature agrees with the results of this study, on the importance of examples.

Goals of Teaching Engineering and the types of skills and attitudes that needs to be learned

The participants mentioned that one of the goals of teaching engineering is developing several skills. The skills they considered most important were critical thinking, problem solving, creativity, organization and teamwork. They also mentioned communication, discipline, responsibility, interpersonal relations, time management and writing skills.

Felder, Rugarcia, and Stice [20], mentioned that acquiring a basic knowledge (n=4), skills and attitudes are part of the goals that should be achieved in engineering education. The main skills mentioned by Felder [20] were engineering problem-solving skills (n=6), creative thinking (n=5), teamwork (n=10), written and oral communication skills (n=7), social awareness (n=3), and critical thinking (n=6); which are all in accordance with the skills mentioned by the participants in our study. Whitmire [21], considers that the development of critical thinking skills plays a significant part of undergraduate education. In Whitmire's study, student's perception of gains in critical thinking was mainly dependant of their perceived college environment, the student background characteristics, and the frequency of library activities.

In order to attain the skills needed, students should be given practice and not just passively listen to what they are supposed to do; as people acquire skills most effectively through practice and feedback [13]. Instructors should serve as coaches, providing constructive feedback and encouraging reflection (recaps) to help students achieve the target attitudes and skills [13]. According to Woods et al. [13] the target skills are: communication skills, teamwork (n=2), management skills (n=5), self-assessment (n=5), problem-solving, and writing skills.

Fromm [3] also mentions in his article, that students must possess: a basic knowledge, capacity to apply, communication skills (n=2), management skills, social and ethical responsibilities, interdisciplinary view, critical judgment skills and enthusiasm for learning, teamwork, and

interpersonal relations.

The study presented by Bjorklund, Parente and Sathianathan [19], examines the faculty teaching practices that are positively related to gains in several design and professional skills, such as problem solving skills (n=4), teamwork (n=3), apply in the real-world, communication skills (n=4), and management skills. The study mentions as effective methods, working in small groups, hands-on projects, student-student and student-faculty collaboration, presentations, writing reports, provide feedback and academic advice.

Teaching methods that work in the classroom

Participants considered effective to present in the classroom examples/applications, clear objectives, information in both concrete and abstract ways, and recaps. Students also valued when the professors were organized and ask for questions at the beginning of lecture. The study participants mentioned as interactive methods, working in groups, in-class demonstrations, experiments, using internet, and any type of activity that is hands-on. They also valued when the instructor acknowledged that things are difficult and help the students simplify the material by providing handouts and giving "time to soak". These comments are consistent with what were proposed in Felder, Rugarcia, and Stice [20] and Felder, Stice, and Rugarcia [22] who considered teaching methods that work in the classroom as having the following features: doing recaps, real world applications, give clear objectives, working in teams, providing handouts or a course pack, and using the Internet.

Summary

When it comes to evaluation of teaching methods, the general feeling is that students would like to see more opportunity to give input in the system. Much can be learned from involving students in the process of educational/instructional development. It is very important to recall that students did acknowledge they are an important part of the system as for every question, the student responses reflect their perspectives, their ideas, needs, and wants.

One word that seemed to be most important to the participants of this study, other than the word "students", is "examples". "Examples" was mentioned by participants, in two of the four brainstorming questions. In the question about educational technology the word "example" came up in the context of creating technology that is interactive and provides real-life examples and technology that allow teachers to illustrate examples. In the question on "excellence in engineering education" participants mentioned that excellence is associated with real life examples and providing more examples. For this question, the word "example" was not only written by 10 out of the 21 participants, but it was also rated by seven of them as one of the top five priorities, in comparison to the other ideas the participants mentioned about excellence. During the focus group discussion the word "examples" was mentioned by participants in four out of the eleven questions that were discussed. The results from this study show that it is important for students to see and work with examples in their engineering courses. The participants ideas and needs reflected in this study, not only showed that examples are being used in the classroom, but that students want to see more examples because it is a method that works for them.

Research literature on excellence in engineering education stresses the importance of skills and knowledge, but leaves out the technology component and the building of relationships that seem to be important to the participants of this study. "Technology" was written by the 8 of the 21 participants of this study as one of the things that came to mind when they thought about excellence in engineering education. One participant associated technology with computers, and two other participants wrote specifically that up-to-date technology was associated with excellence.

Another component of excellence that five participants of this study mentioned, was the issue of community, four of whom also ranked it as one of the five most important issues regarding excellence in engineering education. The ideas that were summarized under community were in terms of contributing and impacting the community, having excellence in the educational community and in its people/students/peers, and having a community of engineers. Closely examining the definition of the word "community" on the dictionary [23] we can find the following: (a) unified body of individuals; (b) the people with common interests living in a particular area; (c) an interacting population of various kinds of individuals (as species) in a common location; (d) a group of people with a common characteristic or interest living together within a larger society. Many of these definitions could be applied to the academic environment where there are people with common interests within the different areas of study (academic department), interacting under a common location (classrooms). From this definition the word interaction jumps out, as it was one of the questions discussed in the discussion group and as mentioned in the beginning of this section it was one of the important aspects raised by participants of this study. Not only are the interactions by student and professors important in the learning process but also in the creation of a community of learning and peers.

Overall, from the standpoint of the participants in this study, excellence in engineering education was described or characterized as: clear, complex, comprehensive, detailed, diverse, efficient, interactive, international, multidisciplinary, personalized, precise, scientific, specialized, and stimulating. The use of common language between the different research programs and researchers in the area would support a unified and comprehensive definition of what is considered to be excellence in engineering education.

From the results obtained in this study, there were also differences in the keywords used by gender. A future work in this area could give us insights as to why there was not only a difference in the use of words but in the ranking of what are important ideas in engineering education, by gender and understand if the differences are statistically significant.

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