A Glimpse of How Freshmen Engineering Students Understand Engineering as a Profession

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Abstract

The awareness that engineering is a profession is typically understood by practicing engineers, but may not be perceived in the same way by freshmen engineering students. Freshmen students may not immediately associate engineering with a "profession" but rather with a vocation or trade. With this in mind, Mercer University implemented a freshmen course titled EGR 108: Professional Practices to teach professional and ethical concepts and skills. Mercer Engineering and Technical Communication professors developed research questions and a survey regarding entering freshmen students' understanding of professions. This paper will report the resulting data as a means of qualifying the freshmen engineering students' understanding of professions. Data will also be used to modify the EGR 108 Professional Practices course as needed.

Introduction

The awareness that engineering is a profession is typically understood by practicing engineers, but may not be perceived in the same way by freshmen engineering students. Freshmen students may not immediately associate engineering with a "profession" but rather with a vocation or trade. The importance of equipping young engineering students with the awareness that engineering is indeed a profession, along with its professional characteristics – both in active practice and ethical responsibilities – cannot be overstated.

Indeed, four of the Accreditation Board for Engineering Technology (ABET) program outcomes for assessment relate to professional skills that undergraduate engineering students should develop during their engineering education. These skills involve understanding the impact of engineering in a global and societal context, understanding professional and ethical responsibilities, functioning on multidisciplinary teams, communicating effectively, and committing to lifelong learning. With this in mind, Mercer University implemented a freshmen course titled "EGR 108: Professional Practices" to teach professional practices and ethical problem-solving skills. Mercer Engineering and Technical Communication professors developed research questions regarding entering freshmen students' understanding of professions, including the following:

1. What do freshmen engineering students understand about professions?
2. Are they able to correctly identify the major professions?
3. What do they understand about the differences between professions and trades?
4. What do they understand about the typical things engineers do?

This paper will report the results of a survey given to freshmen engineering students to attempt to answer the questions above. These data will both qualify and quantify the freshmen engineering students' understanding of professions and will also be used to revise the EGR 108 Professional Practices course as needed.

Background – The Professions

The idea of a profession devoted to a specific form of work and status was born long before the field of engineering took prominence as a unique discipline. The early areas of status and power were concentrated in medicine, law, and the clergy; within these, the efforts that individuals undertook to achieve an advanced level of standardized knowledge and skills gradually grew along with the expansion of industrial America.

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Over time, professions took on defining characteristics that set them apart from skilled or technically-oriented work, i.e., trades in which tasks are done by craftsmen or artisans. These characteristics have been studied, analyzed, and compiled into a consistent set of descriptors with the distinct purpose of unifying what it means to be a professional person. Although various elements of the literature describe professions differently, there are core characteristics found repeatedly throughout many different studies and expositions investigating this topic.

For example, Vickers (2001) wrote that professionals are set apart from a mixed-class of "client-employers" and the "self-supporting populace" by several elements. He describes professionals as having special skills in understanding and designing situations, while also having authority as an advisor. He states that professionals operate within the scope of situations based on standards of excellence, maintain a body of specialized knowledge, and are obligated to uphold special responsibilities to clients and laymen. Vickers adds that all professions develop codes to guide their members to work within limits of professional conduct. Similarly, Cruess and Cruess (1997) writing from the perspective of the medical profession, are concerned that doctors may not have a clear understanding of what patients expect from them as a professional, practicing physician. They cite the research of others that reports the importance of independence (or autonomy), along with expertise, ethics, and service. Linking the concept of independence to that of self-regulation is also key to defining what it means to be a professional.

Johnston, Gostelow, and King, (2000) explore the question of what it means to be a professional by contrasting occupations and trades with modern professions. These authors define the word "professional" as having its origin in the Latin word "profiteri", meaning to declare aloud or profess a vocation or special calling. In this sense, the term profiteri is related directly to religious service. Today this term contrasts with work done by amateurs (i.e. within trades) and also indicates thoroughness and competence. Alternatively, trades typically represent occupations chosen through apprenticeship or observing the work of others, not necessarily via a sense of calling or profession. A strong ethical dimension of professional service also distinguishes professions from trades, as already confirmed earlier in the work of Cruess and Cruess.

Johnston, Gostelow, and King list specific characteristics of professionals that are confirmed in many other studies of this topic. In order, they cite that professionals have substantial intellectual and professional training, professional autonomy and responsibility, registration or licensing in their field, fiduciary relationships with clients, and professional indemnity. Over time, it is clear that the loosely organized but respected disciplines of years ago have evolved into regulated, standardized, and focused professions.

Engineering as a Profession

But what about engineering as a profession? What characteristics does it meet, and how can those characteristics be defined and verified? Do engineers see themselves as professionals? Neville Holmes (2002) writing about the information technology profession, states that "In traditional branches of engineering, professionals lead and take responsibility for the work of those skilled in particular trades…" (p. 102-103). Holmes goes on to say that "…engineers and tradespeople have distinct and essential roles" (p.102). In general, Neville believes engineers provide leadership through their education and experience, while tradespeople complete tasks using tools and techniques. The Journal of Professional Issues in Engineering Education and Practice (Johannes Paul, M. 1999) suggests that just like physicians and attorneys, engineers must constantly distill significant information from a specialized body of knowledge, while also staying current with new trends.

Guerin (1991) writes that the core profile of a engineer does not exist, at least in the international realm. He does believe that an engineer "…practices his or her calling in the field of applied science…". To recognize or practice a calling, suggests Guerin, engineers must have a knowledge of basic scientific disciplines and their specialties. This resonates with much of the insistence on a core body of knowledge discussed earlier.

Rochester (2001) writes that engineers "become professional", not so much by their education, but by demonstrating professional behavior in practice. She states that engineers become professionals by meeting six defining characteristics. First, ***theory, skills, and education*** are essential; students move through a rigorous four-year curriculum and then must maintain technical competence in practice. Second, engineers must have both ***authority and autonomy***; they must take control of their work and accept responsibility for the quality of its outcome. Community sanction via ***licensing and certification*** is another professional characteristic. Controlling who enters

the profession and their subsequent behavior is provided by community sanction, which allows the public to respect and trust engineers. When engineers consider and follow both ***personal and professional ethics***, whether as part of an organization or as an independent engineer, professionalism takes on a higher level – that of conforming to a higher moral code that guides practice. Engineers also have a natural ***culture*** that supports official and unofficial associations. Typically, all professions have a culture that represents some sort of shared history and experience that sets it apart from other fields of work. Finally, an orientation toward ***service*** is key to professionalism. Engineers have a professional obligation to work for the good of society; in fact, this is sometimes part of the ethical codes guiding the practice of engineering.

Four of the ABET outcomes for assessment relate directly to what are considered to be professional skills. ABET requires that four-year engineering schools produce graduates who understand the impact of engineering in a global and societal context as well as professional and ethical responsibilities. ABET also assesses programs that teach engineers to function on interdisciplinary teams, communicate effectively, and become lifelong learners. Again, much of ABET's guidelines agree with preceding discussions of engineering as a true profession.

The significance that ABET places on teaching professional skills in engineering cannot be overstated. When engineering students graduate from ABET-accredited schools, we assume that they understand that engineering is indeed a profession and that they must adhere to the responsibility of professional practitioners.

How Freshmen Engineering Students Understand Professions

Perhaps we need to examine the awareness of freshmen engineering students at a more fundamental level. First, are freshmen able to correctly identify the major professions, and can they articulate the differences between professions and trades? Based on the literature, there are distinct differences. But how well do incoming engineering students understand these differences? Beder (1999) suggests that high school students typically have little understanding of what engineers actually do. She sites surveys indicating that students "…tend to think of engineering as a job concerned with objects and gadgets rather than people" (p.13).

Beder suggests that schools of engineering have projected an image typified by numbers, science, and mathematical analysis. This, she believes, has led to a stereotype of engineers as narrow practitioners indifferent to communicating with society. Beder believes that another influence of engineering schools that may impact students' understanding of professions is the reliance on a heavy load of technical subjects divorced from a social context. The result is a field of study only chosen and understood by a targeted audience of students willing to disregard the stereotype – or those students who meet the prescriptions of the stereotype.

Based on this literature and personal observations, the premise of this paper is that freshmen engineering students may not adequately understand the concept of professions, the distinctions between professions and trades, and the awareness of engineering as a profession. Specific research questions were as follows:

What occurs in the four-year university process that builds professional engineers? Rochester (2001) claims that engineers "become" professionals. Does the knowledge of professional behavior come through this educational process over the four years of traditional curriculums? What do freshmen engineering students understand about professions, and particularly engineering as a profession? Can they distinguish profession from trades? Would this data be useful in establishing a baseline awareness from which universities need to build professional education?

Investigating and obtaining generalizable answers to these questions may contribute to engineering education by allowing engineering schools to cultivate professional awareness in students at an earlier stage of their education. Whether this awareness is cultivated through creating a single course or embedding it into existing courses is not the most important decision. The real issue is determining if there is a need, and if so, addressing it within the curriculum to best extend students' understanding.

Research Method

In order to examine the understanding of freshmen engineering students related to professions and more specifically, engineering as a profession, a questionnaire was developed and administered at Mercer University's School of Engineering during the fall of 2002. Mercer University is a private church-affiliated university and its School of

Engineering has approximately 500-600 students annually. Survey participants were anonymous, but the questionnaire did collect demographic data on gender and the actual college year level of the students. Each participant was asked to examine a list of professions and trades chosen randomly from the occupations codes in the United States Department of Labor Standard Occupational Classification Manual (1998). Participants were asked to label each as either a "P" (profession) or a "T" (trade). Unstructured questions were also included to gather data on students' understanding and perceptions of professions and trades, the process of becoming a professional, characteristics and responsibilities of professionals, and the typical, most frequent tasks of engineers.

The questionnaire was administered to freshmen students enrolled in a professional practices course within Mercer's School of Engineering. The sample consisted of 83% males and 17% females with school years ranging from freshmen to junior. As expected, the majority (77%) were freshmen, but surprisingly, six students were sophomores and one student was a junior. The questionnaire featured one broad question asking participants to identify each career field as a profession, trade, or both. Additionally, unstructured questions were included to solicit open-ended responses. Data were compiled and analyzed in both summative and coded form.

Survey Results

The list of career fields presented in the questionnaire ranged from architect to farmer and contained almost all known engineering disciplines as well as scientific and public service areas as well. Table 1 shows the career fields and the identification of each as profession, trade, or both by the participants.

Table 1
Summary of Freshmen Identification of Jobs by Profession or Trade

	Prof.	Trade	Both		Prof.	Trade	Both
Architect	23	6	-	News Reporter	12	17	-
Drafter	12	16	-	Writer	10	19	-
Engineering Technician	19	11	-	Minister/Priest/Rabbi	18	11	-
Aerospace Engineer	27	3	-	Mechanic	9	19	-
Agricultural Engineer	27	3	-	Counselor	19	10	-
Biomedical Engineer	28	2	-	Computer Programmer	27	2	1
Chemical Engineer	28	2	-	Statistician	18	10	-
Civil Engineer	28	2	-	Electrician	12	16	-
Computer Hardware Engineer	26	4	-	Teacher - Secondary	21	8	-
Electrical Engineer	28	2	-	Teacher - Postsecondary	26	3	-
Environmental Engineer	28	2	-	Lawyer	27	2	1
Industrial Engineer	28	2	-	Pilot	21	8	-
Materials Engineer	26	4	-	Chef	8	20	1
Mechanical Engineer	28	2	-	Scientist	27	2	1
Mining & Geological Engineer	27	3	-	Psychologist	27	2	1
Nuclear Engineer	28	2	-	Physician	27	2	1
Petroleum Engineer	28	2	-	Physicist	26	3	-
Artist	5	23	2	Salesman	5	23	-
Cosmetologist	10	20	-	Astronomer	20	9	-
Firefighter	12	18	-	Nurse	19	10	-
Designer	11	19	-	Veterinarian	27	2	1
Actor	9	21	-	Pharmacist	25	4	-
Producer	15	15	-	Chiropractor	26	3	-
Director	15	15	-	Paramedic	17	11	-
Police Officer	16	13	1	Accountant	18	11	-
Athlete	10	19	1	Financial Manager	20	9	-
Coach	8	21	1	Tax Collector	11	18	-

Umpire	9	20	1	Probation Officer	11	18	-
Dancer	12	18	-	Insurance Agent	11	18	-
Travel Agent	13	17	-	Librarian	9	20	-
Singer	9	19	1	Postal Worker	9	19	-
Photographer	8	20	1	Farmer	9	19	-

Unstructured, open-ended questions were used to gather data on students' understanding of professions and their related characteristics. Eleven unstructured questions were included in the survey, with completed responses ranging from N=27 to 30. To avoid bias, responses reported in this paper were chosen through random number generation. The responses to each question were numbered sequentially. Using a uniform distribution with one variable and parameters between one and the highest N, four random student responses were identified for each question. These questions and answers appear in Table Two.

Table 2
Summary of Open-Ended Survey Questions and Answers

Survey Questions	*N=*	*Randomly Selected Responses*
1. Define the term "profession".	30	1. Job for life 2. A specialized trade 3. A profession is a trade in which a person is specialized in and is paid for 4. A high-level career
2. Define the term "trade".	30	1. A specific skill that a person has, such as metal working or candle-making. It is not as developed as a profession. A profession is made of a trade. 2. Something that someone can learn to do. 3. Trade is an ability to do something in a certain field. 4. The kind of work one does that he learns by doing and observing.
3. List and describe the characteristics of a profession.	27	1. Knowledge, trained, professional, established 2. Can live off of it; is a trade 3. Lots of schooling, is usually a doctorate degree and a professional society that oversees testing and a code of conduct and morals for their profession 4. Post secondary education and on the job training
4. Describe the process that one goes through to become part of a profession. How does a person know when he/she has become a member of a profession?	28	1. Years of study/training 2. Goes to school to learn how to perform at levels of excellence to be good at something. Gets a job somewhere and puts their training to work. 3. Education then work in a field or profession. I think one just chooses a profession. 4. Training, observation, ask questions. One becomes a member when he/she finds himself doing what is required by the profession.
5. Describe the characteristics of a "professional" person.	27	1. They base their work and judgment on personal and business code of ethics 2. Responsible, intelligent, lots of training 3. Well dressed; people person; well spoken; knowledgeable 4. It depends on the profession but hopefully responsible and trustworthy. They should be knowledgeable in

		their profession.
6. Describe the responsibilities of a "professional" person.	28	1. Get things done 2. Must know everything in their field 3. Loyalty, quality of work, ethics 4. On time, dependable
7. In general, how many years of schooling and what type are required to become a member of a profession or a trade?	30	Profession 1. High school plus 4-8 years 2. 4 or more 3. At least 4 years of college 4. College Trade 1. None 2. About 2 3. 2 years at technical school or as apprentice 4. High school and training courses
8. What are the top three things that engineers typically do?	29	1. Design, build, manage, oversee 2. Invent, design, hold meetings to explain their invention or design 3. Design, improve, build 4. Performs, provide solutions to problems, help society
9. What is the typical career path of an engineer?	27	1. High school, college (engineering), masters (optional), get job, move up the ladder 2. Start of working as builders the early year then become manager 3. To intern and be hired by their intern 4. Electrical
10. What additional skills do you think you will need to become a successful engineer – beyond what you may learn in college?	29	1. There is no way to learn exactly what it is like until you are working there. You can get a glimpse by an internship. No one can be told what the matrix is… you have to see it for yourself. 2. How to work in your work place. 3. Work experience at various other related jobs with related job features 4. Good people skills; always have a smile; work well with groups
11. List some descriptive words that best describe a successful engineer.	29	1. Intelligent, resourceful, brilliant, ingenious 2. Talented, smart, math-minded 3. One that is most educated or trained, experienced, and knows how to do their job 4. Smart, happy, trained

Interpretation/Analysis

Identification of Jobs as Professions or Trades

Table I indicates that a majority of survey participants associated the grouped engineering jobs (aerospace through petroleum) with a profession. Some confusion existed on the job of Engineering Technician, with 19 respondents labeling it as a profession and 11 as a trade.

Considering the characteristics of professionals cited by Johnston, Gostelow, and King (2000), Guerin (1991), Vickers (1974), and Rochester (2001), the results of Table I demonstrate some misconceptions of professions vs. trades. Although survey participants did broadly associate engineering job titles with a professional capacity, they were evenly tied on producer and director – jobs which require both artistic, management, and some scientific skills and in which a professional degree may be desired but not required. Additionally, participants identified news reporter as a trade, while many newspapers and publications require at least a bachelor's level degree in journalism. Another notable discrepancy is in the almost unanimous assignment of computer programmer to the status of profession; while many programmers may have earned advanced degrees and meet some of the typical characteristics of professions, this field may be entered by individuals with no post-secondary education. On-the-job or self-training may be sufficient for success in programming, and to date there are no widely known licensing or certification requirements for programmers entering the field – although there are software and hardware certification programs that may enhance the marketability of individuals in this field.

Interestingly, more than half of the respondents assigned paramedics to the professional category, even though paramedic education can easily be obtained at a "trade" school. And, respondents indicated that probation officers, tax collectors, and librarians are trades rather than professions. While the status of probation officers and tax collectors may be undetermined, clearly librarians belong in a professional category; this career field requires a post-secondary degree and there are professional societies governing (and aiding) the professional development of those individuals working in this field.

A survey option was included to allow participants to dual-label a career field as both a profession and a trade. Those fields labeled as both by some participants included artist, police officer, athlete, coach, umpire, singer, photographer, computer programmer, lawyer, chef, scientist, psychologist, physician, and veterinarian. Apparently, some participants indicated an inability to determine if certain career fields were exclusively delineated within the boundaries of a profession or a trade. One conclusion to be drawn from this dual-labeling is that a knowledge gap regarding professions/trades may exist within the survey participants. Another consideration, potentially more generalizable beyond these survey participants and their responses, may indicate that some fields may not be as easily defined as a profession or trade by a given set of characteristics.

Summary of Open-ended Questions and Answers

A more expansive window into participants' understanding of professions vs trades is contained in Table 2. The first two questions, asking for definitions of the term "profession" and "trade", provide intriguing glimpses into students' perceptions. When asked to define "profession", randomly selected responses used the phrases "a specialized trade" and "a trade in which a person is specialized in and is paid for". When asked to define a trade, one participant stated "…a profession is made of a trade." Interestingly, participants assigned the term "trade" to define a profession and vice versa. Other participants defining the term "trade" listed answers such as specific skills, something that someone can learn to do or work one does by doing and observing – all characteristics mentioned in the literature as typically associated with trades. These answers are partial evidence of conflicting perceptions of the distinctions between professions and trades.

When asked to describe the characteristics of a profession, participants identified more specific traits. Characteristics listed included advanced schooling, an overseeing professional society, and a code of conduct and morals. Still, one participant related a profession to something that someone can live off of – as in a trade. A minor pattern emerged in this data that participants were not able to adequately narrow the differences between professions and trades to a precise characterization.

Becoming a Professional

Participants were also asked to describe the process of becoming a professional. Three responses indicated a process of education and then work, and one response only targeted training, observation, and asking questions – and then suggested that one only becomes a member of a profession when one finds himself doing what is required by a profession. This respondent could possibly be thinking in the mode of "you are what you do" rather than the process of growing into a professional through education and practice. When describing the characteristics and responsibilities of a professional person, participants did include ethics, training, responsibility, loyalty, and even well-dressed and loyal. One participant stated that professionals must "know everything in their field", which is a high calling even for the most dedicated professional. Again, these responses suggest only an entry-level

understanding of the characteristics of a professional – which partially confirm this paper's premise that this sample of freshmen engineering students, if representative of most engineering freshmen as a population, may indeed not be able to understand or differentiate between a profession and a trade and engineering itself as a true profession.

Years of Schooling and Descriptors of Success

For the most part, participants correctly estimated the years of schooling required to become an engineer, along with three of the usual things that engineers typically do, such as problem-solving, designing, and building. Similarly, participants responded well to the "typical career path" question, mostly summarizing an educational, then intern, then full-time hire process. Whether participants can then associate the required college years, typical duties, and career path with engineering as a profession is unknown, but does not correlate well with their answers to questions 4 and 6 in Table Two. Questions 10 and 11 do not necessarily correlate to an understanding of engineering as a profession, but do shed light on participants' views of how they perceive continuing education and descriptions of successful engineers. When asked to list additional skills (beyond college) necessary for success, the four responses indicate work experience and people skills, and one respondent said that essentially, you can't learn anything new until you get to your workplace. Words describing successful engineers ranged from intelligent and brilliant to happy and trained – descriptors that indicate a hopeful attitude toward the workplace.

Conclusion/Recommendations for Future Research

Clearly, this study provides conflicting evidence regarding how freshmen perceive engineering as a profession – and on a more fundamental basis, how they distinguish between professions and trades. Table One indicates that, with a few exceptions, most participants were able to adequately assign job titles to the correct category of profession or trade. Yet Table Two suggests that participants were less able to verbally distinguish between professions and trades, stumbling on the distinction between them in regard to their definitions, characteristics, and responsibilities. Table Two also is an indicator that participants may have an inflated view of how engineers are described; calling engineers brilliant and talented is certainly fair, but these descriptors may not always be supported so widely in the larger industrial and technical world.

The premise of this paper was that freshmen engineering students may not understand professions or engineering as a profession. Our conclusion is that for the most part, they do not. In turn, we asked if engineering students can identify the major professions and whether they can distinguish between professions and trades. We also asked if freshmen can adequately describe what engineers typically do. From these results, we concluded that the participants do not have the ability to fully define and distinguish between professions and trades but are able to correctly categorize most of the listed occupations. Perhaps identifying occupational fields as a profession or trade is more straightforward than attempting to explain why an occupation is a profession and describe its characteristics and responsibilities. And, it may be that the participants in this study were biased to identify engineering as a profession because of their interest in the field – yet despite this possible bias, they were not able to adequately explain why they identified it this way.

The results also indicate that participants are able to generally explain the characteristics and responsibilities of professions, but may have a somewhat inflated view of engineering's duties and descriptions of success. Again, participant bias due to interest in engineering may be at work, driving up expectations of success and status in society.

It should be noted that the sample size in this research study was small and drawn from a limited population. While the study was initially undertaken to investigate how well EGR 108 students understood professions, the data obtained indicate that a larger sample size will provide more compelling answers to the research questions. To better investigate these questions, we recommend that this study be repeated with a larger sample size across a larger population of freshmen engineering students – and that the sample be limited to freshmen students only. Another recommendation is that the survey be conducted in the beginning of the first semester of the freshmen year, when EGR 108 begins, and then again at the end of the semester to measure any changes in understanding and perception regarding professions. Finally, it is recommended that a similar study be conducted with senior engineering students. Comparing senior data with freshmen data would yield important clues about the growth of engineering students into the engineering profession throughout their college career.

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