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Technology Interests of First-Year ECE Students

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Introduction

Typically, university engineering study is categorized into specialty areas, e.g. civil, chemical, computer, electrical, mechanical, etc. Engineering students are asked to select a major in one of the engineering specialty areas upon matriculation or soon thereafter. Previous research has shown that significant factors influencing choice of major for college students include (i) general interest subject; (ii) family and peer influence; (iii) assumptions about introductory courses, (iv) potential job characteristics, and (v) characteristics of the major. It is also known that stronger student identity is correlated to persistence. Identity can be strengthened by a program's demonstrated relevance to student interests and motivations.

The authors teach an introductory course in electrical and computer engineering that directly addresses several of major choice factors listed above, namely (i), (iii) and (v). While the students in the course have predominantly already selected computer engineering or electrical engineering as their field of study, there are a number of students enrolled in the first-year course who are exploring the fields of computer and electrical engineering in their search for a major. The authors collected data on the student technology interests from 866 students over a nine-year period. Students self-selected a technology or contemporary issue about which they had to give a short presentation to the class. Student interests were categorized into twelve broad categories, and linguistic analysis done to identify the most commonly used nouns. Electrical engineering majors are more likely to choose energy technologies, while computer engineers a clear preference computing technology and devices. Both genders demonstrated approximately equal interests in medical and energy topics. Men were more likely to have interests in computing, fundamental advances in electronic devices, and space. Women expressed more interests in robotics and solutions for home, society, and safety.

Background

ABET defines engineering as "the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind".

With this definition, one can view the different disciplines of engineering as bringing to bear mathematics and their respective natural sciences to form a solution. Chemical engineers would employ lots of chemistry, civil and mechanical engineers would naturally use Newtonian physics, electrical engineers would employ solid-state physics and electro-magnetics, computer engineers would use more computer science, etc. With such an interpretation, engineers in the different sub-disciplines are very much alike with some small differences. It would be reasonable to assume that students entering study of these fields of engineering would also be very similar with some small differences. Engineering students are a population are not completely homogeneous. Research bears this out.

In [11], the authors found students enrolled in specific engineering disciplines expressed different affinities for different fields of science, and were varied in their perceived practicality of the different engineering disciplines. For electrical and computer engineers, the authors found that the typical student preferred physics slightly more than most other engineering fields, and reported a self-perceived lower skill level but greater interest in mathematics. ECE students also report a very high interest in "inventing/designing things", and view the work of electrical and computer engineers as being broadly/globally applicable.

A large study [3] noted that open-ended responses from engineering students indicated that 16% of students reported that "helping people" was a factor in their decision to study engineering. Indeed, these university students agree with impact of engineering as expressed in ABET's definition of engineering. About 7% of respondents in this study report that "helping people" was the primary or sole reason for their choice. Students studying biomedical, environmental, materials, and civil engineering are more likely to be strongly driven with altruistic motives. Electrical, computer and aerospace engineering student report being less empathetic. The authors in [3] also examined the degree to which students perceived certain engineering disciplines help people/society. Students reported a belief that engineering disciplines that prioritize helping other most are chemical and biological engineering. Civil and environmental engineering place a moderate priority on helping others, while electrical, computer, and mechanical engineering have the lowest priority for creating solutions to humanitarian problems. It seems that we have a ways to go in educating the public and potential students about how all fields of engineering strive to improve the lot of all humankind.
Another study [12] found that both engineering student and working engineers aspire to serve ultimately in management or leadership roles. (The study did not differentiate between the different fields of engineering.) Such a conclusion would not surprise an engineering educator as most engineering students are intelligent, highly motivated, and exhibit good leadership ability, even as young adults. The study, perhaps more surprisingly, found that student engineers aspire to leadership and management at a greater percentage than working engineers.

As to persistence in engineering, a number of studies [1], [2], [4], [5], [14] found that students' abilities, perception of abilities, especially in mathematics play a big part. Another large contributing factor to persistence is student aspirations and how well the discipline – or more accurately, their perception of the discipline – lines up with their career aspirations and personal interest. To improve retention, engineering programs need to ensure that students recognize how their career aspirations and personal interests align with their chosen field early in their studies. Toward this end, an accurate picture of student interest is needed.

Study Population

The authors teach an introductory course in electrical and computer engineering (ECE) which was created to specifically address (1) provide an orientation and early success skills for university life, (2) introduce ethical considerations in engineering, (3) introduce the profession of engineering, and specifically, electrical engineering (EE) and computer engineering (CpE), and (4) give early technical and hands-on skills required of EE and CpE majors. Students in the course have predominantly already selected computer engineering or electrical engineering as their field of study; however, a number of students enrolled in the first-year course are exploring the fields of computer and electrical engineering in their search for a major. As the introductory course is a prerequisite to later ECE courses, it is taken very early in the student's university tenure. Freshman take the course in their first or second semester at the university. Transfer students often take the course in their first semester at the institution because the course is prerequisite to following courses that compose the longest prerequisite chain through the program.

The population used for this study was the students enrolled in this course over a nine-year period and is composed of 866 students. As the course described here applies toward graduation only for EE and CpE majors, a vast majority of the study population were majoring in EE or CpE. Table 1 shows the breakdown of the study population by declared major as reported by the university's data management system upon the first day of the course. Engineering-Undeclared are students enrolled in the university's college of engineering, but have not selected a specific program of study yet, or enrolled as a "pre-engineering" student in the college of engineering. "Pre-engineering" students often are classified as such because they are remediating some foundational area such as mathematics, English, etc. Undeclared students have not selected or identified any particular major to the university.

Table 1. Declared major of study population (N=866)

Program of Study	Number	Percentage
Aerospace Engineering (AE)	6	0.7%
Agricultural Tech & Business	2	0.2%
Art	1	0.1%
Biological Sciences	3	0.3%
Business Info Systems	2	0.2%
Building Construction Science	2	0.2%
Business Administration	3	0.3%
Business Economics	1	0.1%
Civil Engineering (CE)	3	0.3%
Chemistry	1	0.1%
Computer Engineering (CpE)	313	36.1%
Computer Science (CS)	12	1.4%
Electrical Engineering (EE)	397	45.8%
Engineering Undeclared	4	0.5%
English	1	0.1%
Finance	3	0.3%
Industrial Engineering (IE)	1	0.1%
Industrial Technology	2	0.2%
Information Tech Services	1	0.1%
Kinesiology	2	0.2%
Management	1	0.1%
Mathematics	1	0.1%

Mechanical Engineering (ME)	2	0.2%
Political Science	1	0.1%
Psychology	1	0.1%
Software Engineering (SE)	4	0.5%
Undeclared	70	8.1%
Could not be determined (Unknown)	26	3.0%

Since the course only provided graduation credit for EE and CpE degrees, it is assumed that students enrolled in the course who are not EE or CpE majors fall into one of three categories:
(1) transferring into ECE and enrolled in the course before they officially changed majors,
(2) already enrolled in the course but changing out of EE/CpE with their major change already having been processed, or
(3) taking the course because of curiosity in the ECE profession with no current (or immediate) plans to change their major to EE or CpE.
The membership of non-ECE students into these three categories was not ascertained.

Since all students in the both the EE and CpE programs must ultimately take the course described here, it is not uncommon to see students in a variety of places along their academic career in the course. Table 2 shows the class standing of the students in the course. Data reported here was student's classification on the first day of the course. The data available does not allow us to determine easily each student's true higher education background. For the purposes of this study, it is assumed that students enrolled in the course classified as freshmen are "true freshman" – the authors' institution is the first (and only) institution of higher education in which they have enrolled. This is likely correct for a vast majority of the students in the study, as advising steers them into the introductory course in the first or second semester of study. Non-freshmen are very likely to be transfer students from community college as approximately 40% of all EE and CpE majors in the program transfer to the university from community college. It is possible that some of the non-freshmen students simply delayed taking the course beyond the norm, or that non-freshmen students have transferred into EE or CpE major after some semesters of study in another major. The authors are also aware of a few first semester university students who are sophomore and juniors due to AP course credits and/or dual-enrollment during their high school years. Identifying these rare cases is difficult with the current university data systems.

Table 2. University classification of study population (N=866)

Classification	**Number**	**Percentage**
Freshman	334	38.6%
Sophomore	238	27.5%
Junior	219	25.3%
Senior	50	5.8%
Could not be determined (Unknown)	25	2.9%

The 866 students in the study group were composed of 750 men (86.6%), 91 women (10.5%), and 25 students whose gender was not disclosed (2.9%). Of the 313 CpE students in the study population, 278 (88.8%) were men and 35 (11.2%) were women. Of the 397 EE students in the study population, 357 (89.9%) were men and 40 (10.1%) were women.

Approach

The introductory course taught by the authors is the student's first glimpse into the engineering profession, its sub-disciplines, and technical areas within electrical and computer engineering. The course also emphasizes good university habits, study skills, and reviews fundamental mathematical concepts and skills crucial to early success in ECE: matrices, complex numbers, Matlab, basic DC circuits, troubleshooting, and soldering. The course also has modules on engineering project management and ethics. Classroom lectures employ numerous active exercises and strengthening the student's personal network is heavily emphasized.

About a month into the course, a task was assigned to students wherein they must select a contemporary (within the last twelve months) article about an engineering technology that represented a deep personal interest. While the student selection cannot be ascertained, classroom introductions to the assignment concentrated on the breadth of computer engineering and electrical engineering, and how nearly any hobby, interest, or passion likely employs aspects of computer and electrical technologies. The selected article's content must be accessible to the average university student. Students are encouraged to consider articles in trade publications such as *IEEE Spectrum*, *EE Times*, *Electronics Design*, *Embedded Systems* magazine, *IEEE Potentials*, any of the magazines from an IEEE society of interest, etc. The assignment requires the student to prepare a single visual graphic and a three minute talk on the article's subject. Presentations are made to the entire class in a large lecture hall with each presenter having approximately one minute of Q&A after their presentation. Students are graded by the instructor of record, the course graduate teaching assistant, and the undergraduate mentors assigned to the class. Grading is based on oral and visual presentation, and student understanding of technical content. Furthermore, a classroom response system (clickers or a streamlined Google form) is used by the class members to provide additional feedback to the presenter. Peer feedback contributed a very small portion (~5%) of the student's presentation grade.

The articles selected by the study population over a nine-year period were analyzed. The authors independently assigned each presented article to one of twelve broad subject areas with a "Miscellaneous" category for articles subject that defied characterization.

Automotive or Transportation (AT)
Communications (Cm)
Computer: Hardware and/or software (Cp)
Consumer Products (Cs)
Electric Devices (ED)
Entertainment, Virtual Reality, or Augmented Reality (En)
Medical/Health (Med)
Military and Safety (Mil)

Miscellaneous (Misc)
New Ideas and Methods (New)
Power/Energy (Pow)
Robotics and Automation (Ro)
Space (Sp)

After the initial article classification by the authors, the authors met and came to a consensus to the appropriate category for any student article upon which there was disagreement. Tables 2a and 2b show the distribution of categories of article by population.

Table 2a. Distribution of article categories by population

Category	All (N=867)	Non-ENGR (N=98)	ENGR (N=742)	Non-ECE (N=130)	ECE (N=710)
AT	7.2%	7.1%	7.1%	7.7%	7.0%
Cm	7.5%	8.2%	7.7%	6.2%	8.0%
Cp	13.2%	10.2%	13.3%	9.2%	13.7%
Cs	5.3%	7.1%	5.3%	6.2%	5.4%
ED	5.4%	5.1%	5.3%	6.9%	4.9%
En	7.2%	11.2%	6.6%	10.8%	6.5%
Med	9.9%	8.2%	10.2%	9.2%	10.1%
Mil	1.0%	0.0%	1.2%	0.0%	1.3%
Misc	10.0%	10.2%	10.0%	13.1%	9.4%
New	4.7%	4.1%	4.7%	3.8%	4.8%
Pow	15.0%	12.2%	15.4%	9.2%	16.1%
Ro	10.9%	14.3%	10.4%	13.8%	10.3%
Sp	2.7%	2.0%	2.8%	3.8%	2.5%

Table 2b. Distribution of article categories by population

Category	EE (N=397)	CpE (N=313)	Men (N=750)	Women (N=91)
AT	8.1%	5.8%	7.3%	5.5%
Cm	7.1%	9.3%	7.6%	8.8%
Cp	5.8%	23.6%	13.9%	5.5%
Cs	5.0%	5.8%	5.3%	6.6%
ED	5.8%	3.8%	5.6%	2.2%
En	4.8%	8.6%	7.1%	7.7%
Med	8.8%	11.8%	9.9%	11.0%
Mil	1.8%	0.6%	0.9%	2.2%
Misc	11.3%	7.0%	10.1%	9.9%
New	4.5%	5.1%	4.5%	5.5%
Pow	23.7%	6.4%	15.1%	14.3%

Ro	10.6%	9.9%	9.7%	19.8%
Sp	2.8%	2.2%	2.9%	1.1%

The article titles were analyzed used linguistic text analysis techniques. The Python Natural Language Toolkit (NLTK) was used to remove "stop words". In natural language processing, useless words (data) are called stop words. Stop words are common words typically omitted in search engines and often ignored with alphabetizing titles. Common stop words are "the", "a", "an", "in", "on", etc. Then, words were "stemmed" to collapse variations of words onto the same stem word. For example, stemming combines occurrences of "car" and "cars" to a single entry "car". The next step of analysis was to perform parts-of-speech tagging on the article titles. Each unigram was examined and marked as to its part of speech: "noun", "verb", adjective", "adverb", etc. Only the nouns in the article titles were retained as the study is concerned with identifying technologies of interest. Tables 3a and 3b show the top 20 words for several populations along with the percentage of time that the word was used in the selected article titles.

Table 3a. The twenty most common nouns in article titles by population

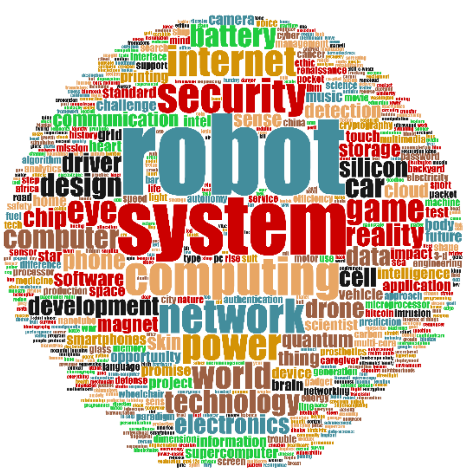
All (N=867)	**Non-ENGR (N=98)**	**ENGR (N=742)**	**Non-ECE (N=130)**	**ECE (N=710)**
system, 2.1%	power, 2.5%	system, 2.1%	power, 1.8%	system, 2.1%
power, 2.1%	system, 1.8%	power, 2.0%	robot, 1.8%	power, 2.1%
robot, 1.7%	communication, 1.4%	robot, 1.8%	system, 1.8%	robot, 1.8%
energy, 1.0%	robot, 1.4%	energy, 1.1%	sensor, 1.3%	energy, 1.2%
car, 0.92%	heat, 1.1%	car, 1.0%	light, 1.1%	car, 1.0%
battery, 0.80%	space, 1.1%	battery, 0.88%	audio, 1.1%	battery, 0.93%
network, 0.73%	detection, 1.1%	network, 0.80%	communication, 1.1%	grid, 0.74%
grid, 0.69%	streaming, 1.1%	grid, 0.71%	eye, 1.1%	network, 0.74%
data, 0.65%	control, 1.1%	data, 0.62%	network, 0.79%	data, 0.65%
security, 0.57%	drone, 1.1%	eye, 0.57%	heat, 0.79%	life, 0.56%
technology, 0.57%	sensor, 1.1%	life, 0.53%	space, 0.79%	security, 0.56%
sensor, 0.57%	player, 1.1%	security, 0.53%	design, 0.79%	technology, 0.56%
eye, 0.54%	laser, 1.1%	sensor, 0.53%	computer, 0.79%	internet, 0.51%
electronics, 0.50%	iPhone, 1.1%	technology, 0.53%	detection, 0.79%	reality, 0.51%
reality, 0.50%	beam, 0.71%	electronics, 0.53%	streaming, 0.79%	cell, 0.51%
computer, 0.50%	hand, 0.71%	internet, 0.49%	control, 0.79%	electronics, 0.51%
internet, 0.46%	traffic, 0.71%	design, 0.49%	drone, 0.79%	phone, 0.51%
drone, 0.46%	delivery, 0.71%	reality, 0.49%	heart, 0.79%	eye, 0.46%
life, 0.46%	computer, 0.71%	cell, 0.49%	player, 0.79%	sensor, 0.46%
design, 0.46%	football, 0.71%	computer, 0.49%	laser, 0.79%	world, 0.46%

The 866 students in the study group were composed of 750 men (86.6%) and 91 women (10.5%).

Table 3b. The twenty most common nouns in article titles by population

EE (N=397)	CpE (N=313)	Men (N=750)	Women (N=91)
power, 3.1%	robot, 2.2%	power, 2.1%	system 2.9%
system, 2.5%	system, 1.7%	system, 2.0%	robot, 2.3%
energy, 1.9%	computing, 1.1%	robot, 1.7%	power, 2.3%
robot, 1.4%	security, 0.96%	car, 0.98%	energy, 1.3%
car, 1.3%	network, 0.96%	energy, 0.98%	impact, 1.3%
battery, 1.1%	internet, 0.85%	battery, 0.94%	grid, 0.99%
grid, 1.1%	power, 0.85%	network, 0.76%	drone, 0.98%
life, 0.82%	game, 0.74%	data, 0.67%	road, 0.98%
way, 0.74%	world, 0.74%	sensor, 0.67%	depression, 0.98%
data, 0.74%	eye, 0.74%	grid, 0.63%	light, 0.98%
sensor, 0.66%	car, 0.64%	security, 0.58%	people, 0.98%
laser, 0.57%	technology, 0.64%	eye, 0.58%	disaster, 0.98%
network, 0.57%	reality, 0.63%	electronics, 0.58%	China, 0.65%
challenge, 0.49%	3D, 0.63%	technology, 0.58%	touch, 0.65%
fuel, 0.49%	design, 0.63%	cell, 0.54%	life, 0.65%
cell, 0.49%	computer, 0.63%	computer, 0.54%	action, 0.65%
device, 0.49%	battery, 0.63%	game, 0.49%	motion, 0.65%
electronics, 0.49%	driver, 0.53%	reality, 0.49%	map, 0.65%
phone, 0.49%	chip, 0.53%	device, 0.49%	development, 0.65%
technology, 0.49%	drone, 0.53%	communication, 0.49%	smartphone, 0.65%

Word clouds showing the relative frequency of the nouns were created for each population studied. Larger words indicate usage that is more frequent. Figure 1 shows the word clouds of the nouns extracted from article titles chosen by computer engineering students and electrical engineering students. Figure 2 shows the word clouds of the nouns extracted from article titles chosen by male and female electrical engineering students.



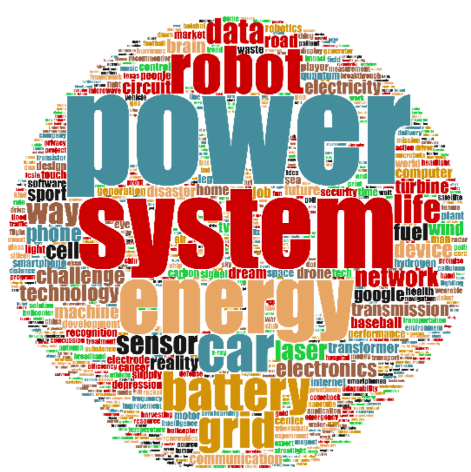


Figure 1. Words clouds composed of nouns extracted from titles of articles selected by computer engineering students (L) and electrical engineering students (R). Larger words indicate increased frequency of usage.

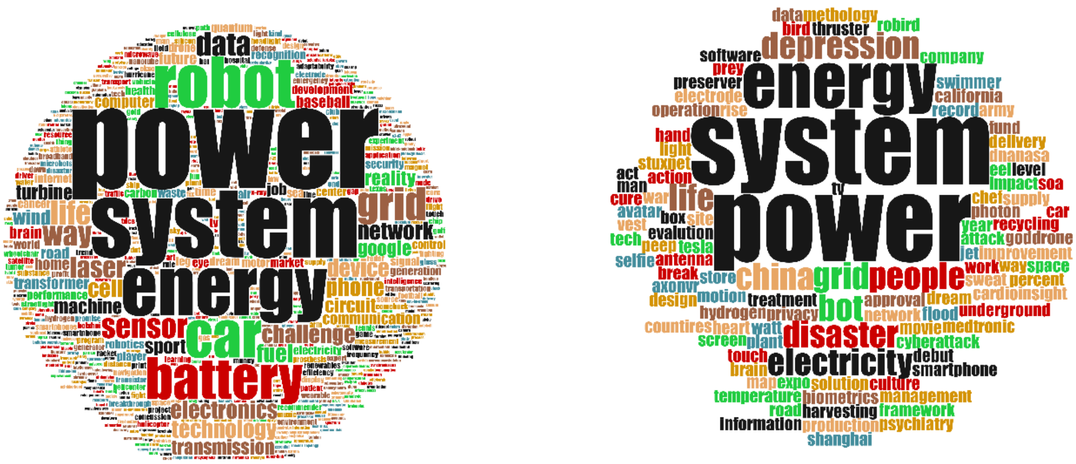


Figure 2. Words clouds composed of nouns extracted from titles of articles selected by male electrical engineering students (L) and female electrical engineering students (R).

Results and Discussion

Students were instructed to select an article about technology that was most interesting to them. The selected article had to be contemporary (published in the preceding twelve months) and intellectually accessible to the “average university student. Students are encouraged to consider articles in trade publications such as *IEEE Spectrum*, *EE Times*, *Electronics Design*, *Embedded Systems* magazine, *IEEE Potentials*, *IEEE Computer*, or any of the magazines from an IEEE society of their interest, etc. Scientific journals and conference proceedings were forbidden. The vast publications of the IEEE, ACM, and related organizations provide the student with a reasonable chance of finding a recent article that targets their most fervent interest.
This paper and the included analysis assume that the selected article truly represent the student’s interest. Of course, this is not always the case. Students procrastinate and other students want to simply complete the task and move on. The authors are aware that at least some students simply selected the first article that appeared in a cursory search. However, it appeared that most student were genuinely interested in the subject through body language and energy expressed in their presentations.

Each student-selected article was assigned into one of twelve broad subject categories with a “miscellaneous” category for article subjects that defied characterization. Figures 2a and 2b show the percentage of articles from a few of the population sets examined. It is instructive to consider the different populations by examining the top five categories for each population. Tables 4a and 4b give the top-five most popular categories for several populations.

Table 4a. Five most popular article subject categories by population

Non-ENGR	ENGR (N=742)	Non-ECE (N=130)	ECE (N=710)	CpE (N=313)	EE (N=397)
Ro 14.1%	Pow 15.4%	Ro 13.8%	Pow 16.1%	Cp 23.6%	Pow 23.7%
Pow 12.2%	Cp 13.3%	Misc 13.1%	Cp 13.7%	Med 11.8%	Misc 11.3%
En 11.2%	Ro 10.4%	En 10.8%	Ro 10.3%	Ro 9.9%	Ro 10.6%
Cp 10.2%	Med 10.2%	Cp 9.2%	Med 10.1%	Cm 9.3%	Med 8.8%
Misc 10.2%	Misc 10.0%	Med 9.2%	Misc 9.4%	En 8.6%	AT 8.1%
		Pow 9.2%			

Students majoring in engineering programs (ENGR) expressed similar interests as students majoring in programs other than engineering (non-ENGR). Both populations selected articles in the same categories for four of the top five, with ENGR students expressing a stronger preference (10.2%) for medical (Med) subjects than non-ENGR students (8.2%). Non-ENGR students were nearly twice as likely to select entertainment (En) subjects (11.2%) than their ENGR counterparts (6.6%).

A comparison of students majoring in CpE and EE (ECE) and all others shows similar results. The ECE students were much more interested in the categories of that is the namesake of their major: power (16.1%) and computers (13.7%). Non-ECE students were most interested in robotics (13.8%), entertainment (10.8%), and miscellaneous subjects (13.1%) that spanned disparate categories.

The strong preferences for power and computing topics by the ECE population originates in the signature topic area of the two different programs. Nearly one-quarter (23.6%) of CpE students chose an article on computing, computer hardware, or software. A nearly equal percentage (23.7%) of EE student chose to make a presentation on article about power and energy. Robotics (Ro) and medical (Med) subjects were popular with both CpE and EE students. Articles in these subject areas were about 10% each, with CpE student favoring medical subjects over EE student by almost 3%. Rounding out the top five for CpE students were communications (Cm) and entertainment. A significant portion (11.3%) of EE students chose articles that were in fringe subject areas or entailed several subjects that made them difficult to categorize placing them in the miscellaneous (Misc) category. The fifth most popular subject for EE student is "automotive and transportation" (AT) at 8.1%. The AT articles were popular with all populations; the EE population was the only one where AT broke into the top five.

Table 4b. Five most popular article subject categories by population

Men (N=750)	Women (N=91)	CpE Men (N=278)	CpE Women (N=35)	EE Men (N=357)	EE Women (N=40)
Pow 15.1%	Ro 19.8%	Cp 25.2%	Ro 22.9%	Po 23.5%	Po 25.0%
Cp 13.9%	Pow 14.3%	Med 12.6%	Cm 14.3%	Misc 10.6%	Ro 20.0%
Misc 10.1%	Med 11.0%	En 9.0%	AT 11.4%	Ro 9.5%	Misc 17.5%

Med 9.9%	Misc 9.9%	Cm 8.6%	Cp 11.4%	AT 9.0%	Med 15.0%
Ro 9.7%	Cm 8.8%	Ro 8.3%	Cs 11.4%	Med 8.1%	New 7.5%

The populations of men-only and women-only exhibit many of the same top-five chose subjects as the ECE population because the ECE population composes roughly 82% of the study group. The women did choose robotics subjects (Ro) at more than twice the rate as men. Women were not as keen on computer hardware and software topics (Cp) as men, but demonstrated a stronger preference for medical (Med) and communications (Cm) topics.

Examining the computer engineering population by gender, CpE men chose computing (Cp) more than twice as often as the women, whereas the women CpE chose robotics (Ro) nearly three times more frequently as their men counterparts. Entertainment subjects (En) were more popular with the men CpE students, and women computer engineers selected automotive (AT) and consumer electronics (Cs) subjects more than men. An observation here is that men computer engineering students exhibited a passion for the computer itself and its constituent components: hardware and software by selected the Cp category. Women computer engineers were much less excited about the computer, but rather chose computing applications more strongly especially those applications that have an immediate human benefit: robotics (Ro), communications (Cm), automotive (AT), and consumer electronics (Cs).

In the electrical engineering population, both men and women demonstrated a very strong preference for power and energy subjects, 23.5% and 25.0%, respectively. Outside of power and energy topics, EE men had a wide distribution of interest while the EE women were more focused in their technology interests. EE women were twice as likely to choose robotics (Ro) or medical (Med) subjects as their men counterparts were. No EE women chose automotive or transportation topics while AT was the fourth most popular choice among the men. The EE women were the only population studied where "new ideas and method" (New) rated in the top five. These articles covered engineering development that extended the body of knowledge or discovered new science.

After student presentation topics were categorized into twelve categories, a Pearson's chi-square test (α=0.05) was performed to examine the relation between technology interest category and several population demographic characteristics. The results of the tests are given in Table 5. Where the number of categorical responses were low, that category was omitted. Results indicating a significant statistical relationship are given in italics font.

Table 5. Independence of student interests and demographic characteristic

Populations	**DoF**	**N**	**χ^2 statistic value**	***p* value**
Men; Women	12	841	17.08	.147
Majoring in ECE; not majoring in ECE	12	840	14.82	.252
CmpE Men; CmpE Women	12	313	20.61	.056

EE Men; EE Women	*12*	*397*	*22.54*	*.032*
CmpE Freshmen; CmpE Sophomores; CmpE Juniors; CmpE Seniors	36	313	31.67	.675
EE Freshmen; EE Sophomores; EE Juniors; EE Seniors	36	397	28.98	.791
CmpE Men; EE Men	*12*	*635*	*81.68*	*< .001*
CmpE Women; EE Women	*11*	*75*	*30.80*	*.001*
CmpE Freshmen; EE Freshmen	*12*	*303*	*43.38*	*< .001*
CmpE Sophomores; EE Sophomores	*12*	*176*	*28.71*	*.004*
CmpE Juniors; EE Juniors	*12*	*188*	*26.19*	*.010*
CmpE Seniors; EE Seniors	*10*	*43*	*22.17*	*.014*

A statistically significant relationship between chosen major (CmpE or EE) and the student's technology interest. The difference is most pronounced in freshmen with differences between the two similar programs decreasing as the students progressed toward graduation. Not surprisingly, computer engineering students express a strong interest in computer hardware, software, networking, and data security. Clear applications of computing, such as robots, entertainment, medical devices, communications, and consumer electronics were also very popular. Electrical engineering students expressed a strong interest in power and energy issues along with the associated applications. Student interests between genders is also present, but was much less pronounced than the difference between the chosen program of study. Men tended to be most interested in "cutting-edge" technology, specific technology and devices. Women were more likely to choose applications of technology. Applications chosen by women often had a direct and strong impact on society and daily life, such as robotics and solutions for home and security. Several studies have indicated that retention is related to student interests. Students interested in engineering topics or careers choose engineering as a field of study and largely remain in engineering so long as their interest remains strong [8][9][13].

The article title noun frequencies demonstrated by histograms and words clouds are also instructive in seeing differences between the study populations. The most frequently used nouns in EE article titles are often related to energy: power, energy, battery, grid, cell, fuel, etc. Not surprisingly, CpE students often chose articles that centered on computing technologies (computer, internet, security, chip) and computing applications (robot, game, 3D, drone). Differences in the most frequent nouns in the titles of articles chosen by men and women are also seen. The men's nouns are frequently inanimate objects, specific technologies, or physical quantities, such as car, battery, data, sensor, electronics, computer, game, and device. Whereas, the nouns from the women's article titles tend to be more human-centered: depression, people, disaster, touch, life, action and motion.

Conclusions

The authors teach an introductory (first-year) course required of all computer engineering and electrical engineering majors. In this course, the authors collected data on the student technology interests from 866 students over a nine-year period. Students self-selected a technology or contemporary issue about which they had to give a short presentation to the class. Student interests were categorized and analyzed by chosen program, class, and gender. The nouns from the article titles were extracted and the most common words determined.

Examination of article categories reveals that a statistically significant difference between CpE and EE student technology interest exists. This difference is most pronounced in freshmen with differences decreasing as the students accumulated university credits. Not surprisingly, computer engineering students express a strong interest in computer hardware, software, networking, and data security. Clear applications of computing, such as robots, entertainment, medical devices, communications, and consumer electronic were also very popular. Electrical engineering students expressed a strong interest in power and energy issues along with the associated applications. These results indicate that first-year experiences involving CpE and EE programs will need to strike a balance between these two very distinctive preferences. While the study population had a small (and unfortunately all too common) percentage of women, the analysis indicates that gender interests are also present. Men tended to be most interested in specific technology and devices, and women were more likely to choose applications of technology. Applications chosen by women often had direct and strong impact on society and daily life. This result also indicates that recruitment and retention of women into CpE and EE program may be enhanced by increasing emphasis on applications of electrical and computing technologies that have broad societal impact.

Electrical engineering majors and engineering majors other than computer engineering were more likely to choose innovative technologies, while computer engineers and undeclared majors demonstrated stronger interests in computing technology. Both genders demonstrated approximately equal interests in medical and computing technology. Men were more likely to have interests in cutting edge concepts, while women expressed more interests in robotics and solutions for home and society.

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References

[1] E. Alpay, A.L. Ahearn, R.H. Graham, and A.M.J. Bull, "Student enthusiasm for engineering: charting changes in student aspirations and motivation," Euro. J. Engr. Educ., vol. 33, n. 5-6, pp. 573-585, 2008.

[2] D. Bennett, R. Kapoor, K. Rajinder, and N. Maynard, "First year engineering students: Perceptions of engineers and engineering work amongst domestic and international students," Intl. J. First-Year in Higher Educ., vol. 6, no. 1, pp.89-105, March 2015

[3] A.R. Bielefeldt and N.E. Canney, "Humanitarian Aspirations of Engineering Students: Differences between Disciplines and Institutions," J. Humanitarian Engineering, vol. 4, no. 1, pp. 8-17, 2016

[4] M. Cavalli, L. Stanlake, and S. Tolbert, “Investigation of Retention and Perceptions among Freshman Engineering Students”, Proc. 2007 ASEE Midwest Sectional Conference, 2007.

[5] R. Christensen, G. Knezek, and T. Tyler-Wood, “Student perceptions of Science, Technology, Engineering, and Mathematics (STEM) content and careers”, Computers in Human Behavior, Elsevier Press, 2014.

[6] R.M. Felder, G.N. Felder, M. Mauney, C.E. Hamrin, and E.J. Dietz, “A Longitudinal Study of Engineering Student Performance and Retention. III. Gender Differences in Student Performance and Attitudes, J. Engr. Educ., vol. 84, no. 2, pp. 151-163, 1995.

[7] M. Itani and I. Srour, “Engineering Students' Perceptions of Soft Skills, Industry Expectations, and Career Aspirations,” J. Prof. Issues Eng. Educ. Pract., vol. 142, no. 1, 2016.

[8] B.N. Geisinger and D.R. Raman. “Why they leave: Understanding student attrition from engineering majors.” Int’l. J. Eng. Educ. 29(4), pp.914-925. 2013.

[9] A. Godwin “The Development of a Measure of Engineering Identity”. 2016 ASEE Annual Conference and Exposition. New Orleans. 2016.

[10] National Academies Press, “The Engineer of 2020: Visions of Engineering in the New Century”. 2004.

[11] G. Potvin, Z. Hazari, L. Klotz, A. Godwin, R. Lock, J.D. Cribbs, N. Barclay, “Disciplinary Differences in Engineering Students' Aspirations and Self-Perceptions,” Proc. 2013 ASEE Ann. Conf. and Expo. Paper #7350, 2013.

[12] S.L. Rynes, P.S. Tolbert, and P.G. Strausser, “Aspirations to Manage: A Comparison of Engineering Students and Working Engineers”, Cornell Univ. ILR School, 1988.

[13] P.D. Schreuders, S.E. Mannon, and B. Rutherford “Pipeline or personal preference: Women in engineering.” Euro. J. Eng. Educ. 34(1). pp.97-112. 2009. doi:10.1080/03043790902721488.

[14] V.A. Shivy and T.N. Sullivan, “Engineering students' perceptions of engineering specialties,” J. Vocational Behavior, vol. 67, pp.