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Perceptions of Engineering Education

Abstract

The impact of engineering education seems to be felt in all veins of life. Its vastness and recent developments in and out of the field though, blurs what engineering education is. Inconsistent definitions of engineering education are depicted in the literature. One prominent view positions engineering education as a pipeline for developing future engineers by providing exploration and experimentation at the elementary and secondary educational levels. At the university level, it is viewed as a rigorous learning activity. With the recent creation of programs of Departments of Engineering Education in universities across the nation, a clearer understanding of the scope and definition of engineering education is warranted. To address this need, this presentation will review the results of a study that examined the current perceptions of engineering professionals about the scope and direction of engineering education. Members of three divisions of the American Society for Engineering Education (ASEE) namely, Educational Research Methods (ERM), 38%; Engineering Technology Division (ETD), 33%; and K-12 Division (K-12), 29% were purposefully selected to participate. A majority of the data collected from the 380 respondents was conducted electronically. A series of one-way ANOVA revealed statistically significant differences in several key questions. Implications to engineering education are also discussed.

Introduction and Literature Review

Although engineering education has existed for decades, its definition has remained elusive. Founded in 1893 as the Society for the Promotion of Engineering Education and later renamed the American Society for Engineering Education in 1946, it championed the propagation of engineers[1]. Seely (1999) explained that early pioneers in engineering education were determined to achieve recognition, prestige, and professional status that society accorded to law, medicine, and other professions. To do so, engineers distanced themselves from craftsmen and workers using the certification of higher education[2]. While successful in developing many areas of engineering specialization, debate has continued about the purpose and focus of engineering education. For example, the Engineers' Council for Professional Development (ECPD) authorized a study on how to make engineering a leader in problem solving[3,4]. Borrego (2007; Borrego et al., 2006) pointed out that engineering education should be a rigorous research community of practice[5,6]. Finally, Merill et al. (2006) proposed that engineering should be located at the secondary level to equip high school students with the analytical skills needed to approach to problem solving[7].

A more consistent view of engineering education seems warranted. In an effort to further refine the focus of engineering education, the purpose of this survey research was to determine ASEE members' current perceptions toward engineering education and examine differences based on group affiliations. Research questions included:

1. Do ASEE members differ towards *critical issues* in Engineering Education based on group affiliations?

2. Do ASEE members differ in opinion towards *degree programs needed to meet engineering education challenges* based upon group affiliation?

3. Do ASEE members differ in opinion towards *criteria used for consideration in promotion and tenure for a traditional faculty member* based on group affiliation?

Method

A survey was used to ascertain the perceptions of three ASEE's divisions, ERM, ETD, and K-12. These three divisions were selected because of accessibility and diversity of representation. ERM tends to represent the higher education university researchers; ETD tends to represent 2- and 4 - year college and university faculty; and K-12 represents secondary level interests, such as elementary and high school faculty.

Information about this survey was communicated to members of ASEE's three division during their respective business meetings at the 2007 ASEE convention in Honolulu, Hawaii. Hardcopies of the survey were distributed, although few members were able to complete the hardcopy instrument. A majority of data was collected electronically.

Instrument

The instrument was developed by the authors and pilot tested to a group of 20 educators and engineers and modified based on their feedback. Basic demographic information included division affiliation, gender, Carnegie ranking of participant's institution, years of service in primary affiliation, and whether they were engineering or education faculty was obtained (see Appendix). Next, ASEE members were asked to define engineering education in an open-ended format. Lastly, members were asked to respond to issues about engineering education through a series of items requiring Likert-type responses. Items sought responses about critical issues facing engineering education and degree programs needed to meet engineering challenges using the following 5-point scale: 5=Very critical, 4=Critical, 3=Neutral, 2=Less critical, and 1=Not critical. Questions on promotion and tenure for criteria for faculty (when appropriate), used the following response options: 5=Much more weight should be given, 4=More weight should be given, 3= The proper amount is currently given, 2=Less weight should be given, 1=Much less weight should be given. Likert scale responses were treated as an internal scale to calculate numerical averages[7].

Coding of open-ended questions on perceived focus of engineering education was done by searching for and placing recurring statements that fit in one of three categories, that is, engineering research; engineering practice or application; or general education. It emerged that resulting definitions tended to follow ASEE group affiliations (see Table 1).

Table 1: ASEE affiliate groups summarized definitions

ASEE's divisions	Basic Perception of Engineering Education
ERM	The process, method, and task of transforming human beings to think as engineers. An up and coming new discipline that combines both engineering technical and education issues
ETD	Learning to a depth of understanding "why" engineering science functions as they do. A technically-oriented profession career preparation. Training, design, implement, test modify, manufacture systems (products) that involve technology ranging from software to materials.
K-12	Building an understanding and appreciation of what engineering is and how it impacts society. The usage of science and math to solve everyday problems.

Over 100 members of each of the three ASEE divisions responded to the survey. Over one-third of respondents were female. A majority of respondents (73%) identified with engineering or engineering technology disciplines. Members from doctoral granting institutions composed slightly over half of the sample. Further demographic information is indicated in Table 2.

Table 2: Demographic Description of Respondents

Variable	***n***	**%**
ASEE's Division Affiliation		
ERM	144	38.8
ETD	126	34.0
K-12	101	27.2
Gender		
Female	131	35.4
Male	239	64.6
Academic Discipline		
Engineering	183	49.3
Engineering Technology	110	29.6
Education	78	21.0
Institution Rankings		
Doctoral/Research	195	56.5
Masters	62	18
Bachelors	48	13.9
Associates	40	11.6

Table 3: Critical Issues in Engineering Education based on Group Affiliation

	ASEE								
	ERM			ETD			K-12		
	M	SD	N	M	SD	N	M	SD	N
Recruit students to engineering by including content in the k-12 level [Recruitment]	4.12	.867	103	4.12	.794	77	4.22	.881	64
Improve the retention (persistence, graduation rates) of engineering students [Retention]	4.34	.748	103	3.99	.757	76	4.24	.797	63
Classroom improvements/ curriculum development	4.09	.781	103	3.99	.663	76	4.44	.639	64
Faculty development at K-12 and/ or college level [faculty development]	4.09	.935	102	3.59	1.073	76	4.05	.844	64
Research on how people learn engineering topics [how people learn]	3.82	.989	102	3.99	.835	77	3.89	.961	64
Promote excellence in engineering practice [engineering practice]	3.64	1.051	95	3.33	1.035	72	3.87	.974	61

The perceived critical issue that all three ASEE's affiliated groups were in agreement with was recruiting students to engineering education by including content in K-12 level. The K-12 division compiled the highest mean scores (M=4.44) in this area (see Table 3) viewing class improvements and curriculum development as critical. ERM rated Improving retention of engineering students (M = 4.34) as its highest critical issue. None of the three ASEE affiliate groups viewed promoting excellence in engineering practice as critical.

ANOVA results to investigate the perceptions of critical issues based on group affiliation revealed statistically significant differences on retention p=.009; class improvement p=.001; faculty development p=.002; and engineering practice p=.011. Post hoc Tukey tests revealed that significant differences on retention was between the ERM and ETD groups, p=.007; class improvement was between ERM and K-12 groups p=.006; faculty development was between ERM and ETD groups, p=0.002, and between ETD and K-12 members, p=0.015; and engineering practice was between ETD and K-12 groups, p=.008.

Table 4: Degree Programs needed to meet current Engineering Education challenges

	ASEE								
	ERM			ETD			K-12		
	M	SD	N	M	SD	N	M	SD	N
K-12 teaching credential at the BS or MS level (according to state licensure) [K-12 teach credentials]	3.27	1.064	102	3.51	1.064	78	3.79	.871	62
BS or MS Engineering Education degrees for outreach / diversity/ advising positions [Outreach]	3.71	1.174	102	3.09	1.269	77	3.68	1.066	60
PhD in Engineering Education for research and faculty positions	3.45	1.122	102	2.90	1.234	78	3.45	1.169	62
PhD in Engineering Education for teaching positions	3.79	1.105	98	3.46	1.125	76	3.62	.976	60
Coursework for PhDs in traditional engineering disciplines	3.79	1.105	98	3.46	1.125	76	3.62	.976	60

None of the three ASEE's division rated any of the degree programs needed to meet current engineering education challenges to be critical or very critical (see Table 4). The standard deviation was slightly above 1 and the mean ranged from 2.90 to 3.79. A high mean for K-12 in K-12 for teaching credentials seem to indicate higher interest in teacher preparation than the other two divisions. ERMs high mean (M=3.79) of both PhD in Engineering Education for teaching positions, and coursework for PhDs in traditional engineering disciplines seem to cast allegiance in education and engineering fields. This allegiance could either a problem in feeling torn between two fields of study or strength in accepting them equally. ERM and K-12 seem to share a common position on PhD in Engineering Education for research and faculty positions.

ANOVA results to investigate the perception of degree programs needed to meet current engineering education challenges based on group affiliation revealed statistically significant differences on teaching credentials p=.008; degrees need for outreach p=.001; and PhD for research and faculty positions p=.003. Post hoc Tukey test revealed statistically significant differences on teaching credentials between ERM and K-12 groups, p=.005; degrees need for outreach was between the ERM and ETD groups, p=.002, and K-12 and ETD members, p=.011;

and for research and faculty positions was between the ERM and ETD groups, p=.005; and K-12 and ETD members, p= .016.

Table 5: Criteria used for consideration in promotion and Tenure for a Traditional Faculty member in your field

	ASEE								
	ERM			ETD			K-12		
	M	SD	N	M	SD	N	M	SD	N
Securing funding and publishing on Basic research in engineering (Thermodynamics, nanotechnology, etc.) [research in engineering]	4.04	.894	101	3.24	.964	76	3.81	.776	59
Securing funding and publishing on Basic research in Education (Cognition issues, how engineers learn, etc.) [research in education]	3.90	.882	100	3.67	.839	76	3.98	.707	59
Securing funding and publishing on curriculum development and enhancement [publish in curriculum]	3.56	.988	100	3.78	.858	76	3.92	.677	59

As shown in Table 5, ERM perceives research in engineering as critical (M=4.04). ETDs highest rating is publishing in curriculum development and enhancement (M=3.78), while K-12 rates research in education the highest (M=3.98).

ANOVA results to investigate the criteria used for consideration in promotion and tenure based on group affiliation revealed statistically significant differences on research in engineering p=.000; and publishing in curriculum development and enhancement p=.039. Post hoc Tukey test revealed statistically significant differences research in engineering between the ERM and ETD groups, p=.000, and between the ETD and K-12 members, p=.001; publishing in curriculum development and enhancement was between ERM and K-12 groups, p=0.038.

Conclusion

Based on literature review and the survey, ERM perception indicated that Engineering Education was an avenue for educating engineers that provided holistic education in discipline content, engineering basics and liberal education. Further, open-ended responses strongly suggested that this group viewed engineering education as understanding the uniqueness of engineering cognition, developing experiences that brought about deep learning, and study how experiences allow a student to develop into a reflective practitioner. The perceptions were strong on process and research in engineering education. The perception of dual careers as being an engineer and an engineering educator was widely expressed. The PhD degree in traditional engineering was perceived of importance in this group. The perceived priority for this group was educational research in engineering.

ETD members perceived engineering education and engineering technology education to be a practical application of engineering principles geared towards solving real-world (applied, not theoretical) problems in a hands-on environment. Open-ended responses strongly viewed engineering education as a technically-oriented profession. A master's degree coupled with professional licensure and Industrial experience was perceived to be adequate credentials for faculty. The perceived priority for the ETD members was to perfect the technical aspects of engineering, in particular for solving physical problems.

K-12 members' perceptions seem to hinge on building an understanding and appreciation of what engineering is and how it impacts society, and of preparing and motivating students to become engineers. Open-ended responses provided phrases like integrating STEM into activities, projects, presentations, scoring rubrics, and assessment shared across the members. A broader view included educating both students and the general public on the importance of, process of and implementation of engineering in the world today. K-12 members also viewed engineering education as a research field of teaching and learning. Members of this group were open to the PhD in traditional engineering with interest in teaching or a PhD in education as appropriate for faculty in the field. The K-12 priority was perceived to be incorporating engineering principles in the secondary level STEM subjects.

The pattern of responses aligns with the mission and goals of each division to triangulate our findings. Though the results are somewhat expected, direct comparison across divisions remind us that even across ASEE membership, there is broad range of definitions of engineering education. For future work, authors would want to investigate (a) whether division affiliation perception of engineering education influences individual instruction practices; and (b) ways that various divisions can complement each other and avoid working at cross-purposes.

References

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Appendix

Perceptions of Engineering Education - Instrument

Directions: Please select an appropriate response or complete as needed.

1. Please select one field describing your primary affiliation division: [ERM] [ETD] [K-12]
2. Years of service with primary affiliation division: _______________ 3. Gender: [Male] [Female]

4 Please indicate your academic discipline: [Engineering] [Engineering Technology] [Education]

5 Select basic Carnegie classification of your institution: [Associates] [Baccalaureate] [Masters] [Doctoral]

6 In your own words, define Engineering Education

7. What critical issues should Engineering Education efforts address?

(5=very critical; 4=critical; 3=neutral; 2=less critical; 1=not critical)

- Recruiting students to engineering by including content in the K-12 level 5 4 3 2 1
- Improve the retention (persistence, graduation rates) of engineering students 5 4 3 2 1
- Classroom improvements/curriculum development 5 4 3 2 1
- Faculty development at K-12 and/or college level 5 4 3 2 1
- Research on how people learn engineering topics 5 4 3 2 1
- Promote excellence in engineering practice 5 4 3 2 1
- Other research (women, minorities, etc.) 5 4 3 2 1
- Other ____ 5 4 3 2 1

8. How should each of the following criteria be used for consideration in promotion and tenure for a traditional faculty member in your field?

(5=much more weight should be given; 4=more weight should be given; 3= the proper amount is currently given; 2=less weight should be given; 1=much less weight should be given)

- Securing funding and publishing on Basic research in engineering, e.g., thermodynamics, nanotechnology. 5 4 3 2 1
- Securing funding and publishing on Basic research in education, e.g., cognition issues, how engineers learn 5 4 3 2 1
- Securing funding and publishing on curriculum development and enhancement 5 4 3 2 1
- Securing funding and publishing on engineering outreach activities 5 4 3 2 1
- Other ____ 5 4 3 2 1

9. In order to meet the challenges ranked in question #7 above, into what types of positions should colleges and universities invest?

(5=very critical; 4=critical; 3=neutral; 2=less critical; 1=not critical)

- Tenure track engineering education faculty because it is a legitimate research/teaching area 5 4 3 2 1
- Tenure track engineering education faculty, but only so these people have credibility with other faculty 5 4 3 2 1
- Non tenure track instructor 5 4 3 2 1
- Support staff in engineering, such as, director of a teaching center, or an assessment specialist 5 4 3 2 1
- K-12 outreach director 5 4 3 2 1
- Other ____ 5 4 3 2 1

10. What type of educational background and experience should the person(s) identified as very critical in question #9 have?

11. Which of the following degree programs are needed to meet current engineering education challenges?

(5=very critical; 4=critical; 3=neutral; 2=less critical; 1=not critical)

- K-12 teaching credential at the BS or MS level (according to state licensure) 5 4 3 2 1
- BS or MS Engineering Education degrees for outreach/diversity/advising positions 5 4 3 2 1
- PhD in Engineering Education for research and faculty positions 5 4 3 2 1
- PhD in Engineering Education for teaching positions 5 4 3 2 1
- Coursework for PhDs in traditional engineering disciplines 5 4 3 2 1
- Other ____ 5 4 3 2 1

12. For the degrees you rated highest in the previous question, please rate each of the following curricular components:

(5=very critical; 4=critical; 3=neutral; 2=less critical; 1=not critical)

- Traditional engineering content (thermodynamics, circuits, programming,…) 5 4 3 2 1
- Engineering processes (design, problem-solving, estimation, …) 5 4 3 2 1
- Learning theory 5 4 3 2 1
- Curricular design 5 4 3 2 1
- Assessment 5 4 3 2 1
- Educational research methods 5 4 3 2 1
- Designing and mentoring teamwork activities 5 4 3 2 1
- Other ____ 5 4 3 2 1

13. Please use this space to qualify any of your responses above, or make additional comments on the future direction of engineering education:

Thank you for participating in this study!

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