A Focus on the Scholarship of Engineering Education

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Abstract

During the recent past, ASEE has promoted meaningful discussion on "The Scholarship of Engineering Education (SEE)" at regional and national meetings during a designated "Year of Dialog." Many of the discussions were recorded, and efforts to formally document and analyze the discussions have begun. For example, the dialog at the ASEE section meetings was rigorously documented and presented at both the ASEE Gulf-Southwest Section meeting in Albuquerque in March 2008, and at the ASEE Annual Conference in Pittsburgh in June 2008. The most obvious observation from the data is that the Scholarship of Engineering Education, like Boyer's model of the professorate, has several important domains in which faculty must focus their attention. In addition, a compilation of the data by using weighting factors suggests that there are several major action items that ASEE members can focus on. This paper is a follow up on the "Year of Dialog" data compilation, and offers some data analysis and recommendations based on the author's perspective. A vision of the "Scholarship of Engineering Education" will be presented in an illustration highlighting the various domains of the professorate. In addition, the paper will introduce the current ASEE-wide efforts to produce a document on "Engineering Education for the Global Economy" (EEGE) earmarked for unveiling at the ASEE 2009 National Conference in Austin.

Introduction

In January 2006, the ASEE Board of Directors endorsed the "Rising Above the Gathering Storm" (RAGS) report[1]. RAGS called for wide-scale reform in engineering education to meet the global challenges to America's technological status. Subsequent to the endorsement, a committee was organized to orchestrate a series of events during the following year to address these issues. These series of events, called the Year of Dialogue (YOD), was to be followed by an ASEE report on the crisis facing engineering education. The first public event was a plenary session at the ASEE National Conference in Chicago in June 2006, the so-called "Socratic Dialogue". The panel of experts at this plenary session focused on the Scholarship of Engineering Education (SEE) as a way to address the issues in RAGS. As a follow up, the ASEE Zone and Section leaders were charged to organize a YOD session at each of the twelve ASEE Section meetings during the 2006-2007 academic year. As Table 1 indicates, all twelve Sections hosted a YOD event either in Fall 2006 or Spring 2007. In addition, the Engineering Technology Leadership Institute (ETLI) conducted a YOD session at their meeting, and this data is included here also. Based on rough attendance figures, it appears that over 1,000 ASEE members participated in the YOD discussions during the past year as shown in Table 1

Table 1. Data for the Section Meetings During the YOD.				
Section	**Dialog Date**	**Place**	**Attendance**	**Event**
St. Lawrence (St.L)	November 18, 2006	Ithaca, New York	35	Discussion
New England (NE)	April 21, 2007	Kingston, Rhode Island	35	Discussion
Middle Atlantic (MA)	November 4, 2006	Toms River, New	60	Presentation
	April 21, 2007	Newark, New Jersey	80	Speaker
Southeastern (SE)	April 1, 2007	Louisville, Kentucky	140	Speaker
North Central (NC)	March 31, 2007	Charlestown, WV	60	Discussion
Illinois-Indiana (Ill-In)	March 31, 2007	Indianapolis, Indiana	140	Discussion
North-Midwest (NMW)	October 7, 2006	Menomonee,	50	Panel
Midwest (MW)	September 14, 2006	Kansas City, Missouri	61	Panel
Gulf-Southwest (GSW)	March 29, 2007	So. Padre Island, Texas	151	Panel
Rocky Mountain (RM)	April 20, 2007	Provo, Utah	44	Panel
Pacific Northwest (PNW)	April 27, 2007	Pullman, Washington	50	Panel
Pacific Southwest (PSW)	April 13, 2007	Reno, Nevada	65	Panel
Engineering Technology Leadership Institute (ETLI)	October 7, 2007	Charlotte, N. Carolina	50	Presentation
		Total	1021	

In an effort to coalesce the discussions, several strategies were adopted. First, each Zone and Section Chair was asked to record the YOD panelist/speaker and audience comments during their particular event. These Section notes were then sent to the ASEE Zones YOD Committee, which was co-chaired by the ASEE Vice-President of Member Affairs and the ASEE Immediate Past President. The notes were reviewed, Section by Section, and bulleted highlights of the various discussions were created for further consolidation. General themes emanating from the notes were entered into a spreadsheet table under the title "Topics" and a check mark (√) was placed under each Section that had discussed that particular topic. Once all the twelve Sections were reviewed, and topics were checked, the summation was made to determine the frequency that a particular topic had been discussed across all Zones. Using these observations and data, a draft report was developed and distributed to all Zone, Section and panel leaders involved in the YOD meetings, seeking comments and additional points of view. A carefully edited version of these notes and comments resulted in an ASEE Zone-wide report[2].

Results

There were 42 "Topics" from the YOD that were identified by the committee as sufficiently distinct comments or points of view about SEE. In addition, for consolidation purposes, each "Topic" was assigned to one of five major categories, labeled A-E:

A. Faculty Issues and Rewards
B. Pre-College K-12 and Outreach Issues
C. Curriculum Reform and Evaluation Issues
D. Outside Resources and Influences
E. Research Topics and Issues

The number of times each major category appeared in the 42 "Topics" list was counted and recorded in Table 2. The table also shows the weight factor (frequency X number of √ across all meetings) for each major topic. In addition, Appendix A was formulated by arranging the major categories A-E into separate tables, and then the "Topics" are listed in the order of the number of √ across all meetings.

Table 2. Frequency Count for Major Categories

Major Categories	Frequency	Weight Factor
A. Faculty Issues and Rewards	10	38
B. Pre-College K-12 and Outreach Issues	6	13
C. Curriculum Reform and Evaluation Issues	9	26
D. Outside Resources and Influences	8	29
E. Research Topics and Issues	9	42
Total	42	

Discussion

The RAGS report called for broad reform in K-12 STEM education, and ASEE clearly has an opportunity to be a national leader in K-12 reform, since it impacts engineering education at the college level. K-12 is the pipeline and lifeblood for what we do and how it affects the technology base of this country. Indeed, ASEE has already begun efforts to impact K-12 through a number of initiatives including the all day seminar initiated at the past four national conferences. The YOD on the other hand was an attempt to identify the various aspects of engineering education through research and to build on the momentum started by such schools as Purdue and Virginia Tech, which have started engineering education programs. The RAGS report and the YOD events, as envisioned, were two very different things, but they were and are very much entwined and the discussions at many of the section meetings made that clear.

If one wishes to pursue a pathway to research in engineering education, the research methodology in engineering education should be no different than the same methodological approach used in technical engineering research: 1. define the research question or hypothesis, 2. write a proposal or plan, 3. seek funding or other appropriate support, 4. do the work rigorously, and 5. publish the results in peer-reviewed journals. In this sense, engineering education research should be considered favorably in promotion and tenure. One caveat in educational research is that the student (human subject) is usually the target of study, and it makes the "experiment" more complicated. Thus, it is reasonable to expect engineering faculty to partner with social and learning scientists when conducting SEE research. Indeed, an analysis of recent *Journal of Engineering Education* (JEE) articles indicates that it is already happening. It is likely the same will be true for the new *Advances in Engineering Education* (AEE) on-line journal.

The issues raised by the "Socratic Dialog" at the ASEE Conference Plenary in 2006 were mainly related to research in engineering education. However, the word research in this context brought some confusion to the early YOD sessions. It was misunderstood by the general audiences,

perhaps narrowly defined and not articulated clearly. This is easily seen by the list of topics in Appendix A. It seems preferable to use the word **scholarship** in the place of the word **research.** In this case, the term scholarship should be used in the same way that Ernest Boyer[3] did in his classic monograph "Scholarship Reconsidered: Priorities of the Professoriate." In that document he describes four types of scholarship which seem to be appropriate for this discussion:

1. The scholarship of discovery,
2. The scholarship of integration,
3. The scholarship of application, and
4. The scholarship of teaching.

It may be appropriate to expand the concept of the "Scholarship of Engineering Education" (SEE), in light of the views expressed by Boyer. Some faculty may want to perform rigorous educational research in engineering (Boyer types 1 and 2), while other faculty may prefer to implement new teaching practices (Boyer type 3), and yet others may want to just improve their teaching skills (Boyer type 4) or innovate in the classroom with new technologies. Indeed, the concept of SEE could have many branches, as illustrated in Figure 1. ASEE can take the lead in defining these various branches, put into place efforts to address each of them by our membership, and produce an archive of best practices.

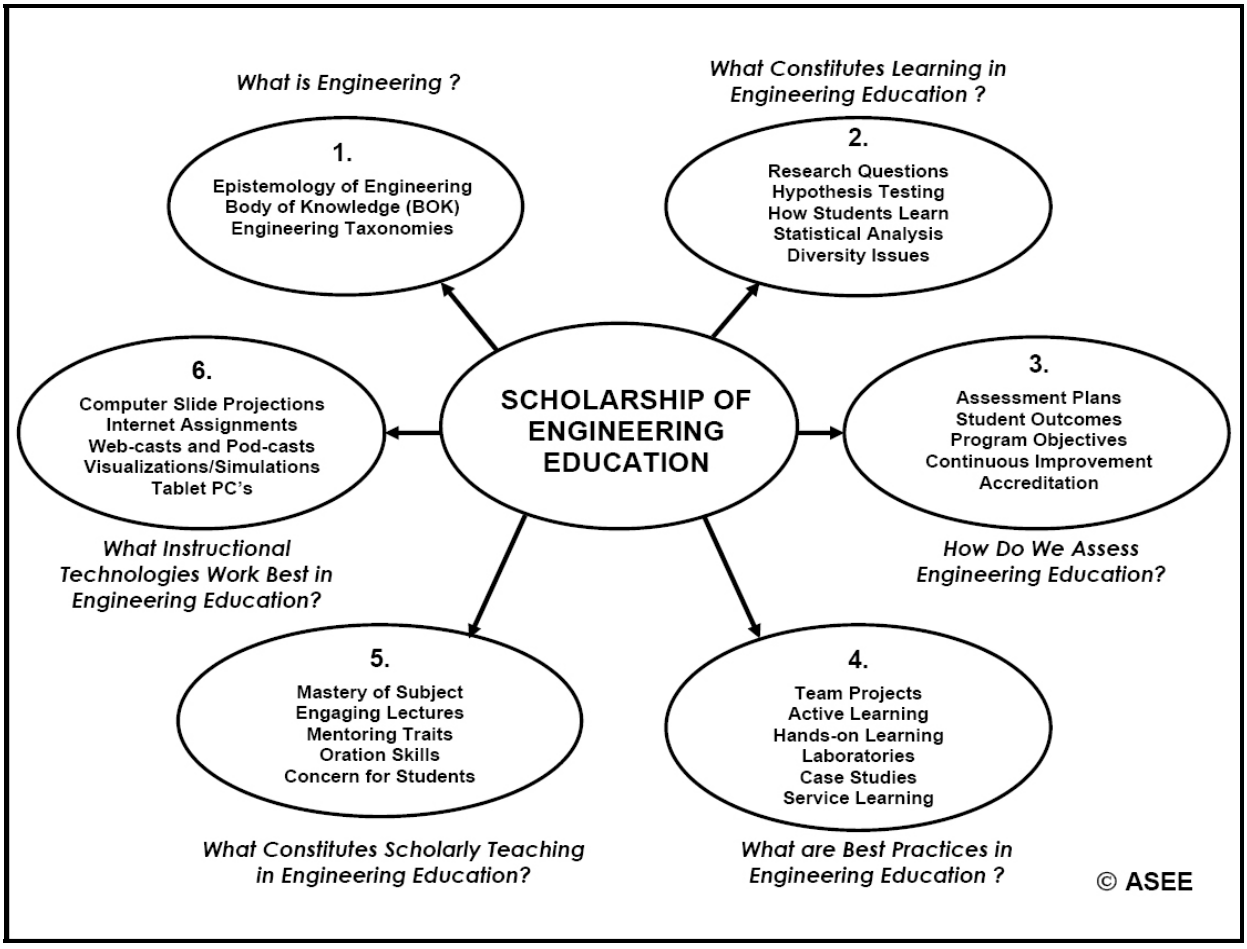

Figure 1. The Scholarship of Engineering Education (© ASEE). Boyer's Four Levels of Scholarship Can Be Mapped Clockwise Around the Branches

In particular, a citation[4] from the Pacific Northwest (PNW) Section meeting seems to have captured the diversity and spirit of YOD thinking, and fundamentally supports the ideas conveyed in Figure 1. It read:

> Dr. Teri Reed-Rhoads (Purdue University) described five areas of engineering education scholarship: (1) knowing what students need to learn, or epistemology; (2) knowing how they learn, or learning mechanisms; (3) knowing how we teach it; (4) knowing how we can be more inclusive; and (5) knowing how we know it works, including assessment. Engineering education needs transformational change, from how we recruit students through what happens to them after they graduate, involving business, academics, and government. The engineering curriculum has changed remarkably little in 100 years. Unlike law, medicine, and policy schools, we have not diversified even our undergraduate programs, while those fields are now working on diversifying their full partners in businesses. "I'm hoping that research in engineering education becomes the engine that drives these changes to improvement."

Recommendations from YOD

While it is possible to write a succinct report which describes the discussions that took place over time and area, it is clear that there are three observations that can be immediately made:

- There are a number of very important topics and issues that emerged from the YOD discussions and they must be discussed in an on-going fashion within ASEE and beyond.
- Actions must be taken to respond to the YOD report and the very important problems facing engineering education.
- There should be a necessary prioritization of these actions, to minimize both time and effort, to achieve a maximum effect.

It is most helpful that some recommendations be made which the ASEE body can use as an agenda in the coming year or two. These include:

1. That the ASEE Board of Directors (BOD) should take time out from business as usual to have a directed study of this YOD report and the many other issues facing engineering education and implement a process to address the most important recommendations.

2. That the ASEE Engineering Deans' Council, the Engineering Research Council, and the Engineering Technology Council discuss these recommendations at its meetings and assist in developing a process for implementation.

3. That ASEE partner with the appropriate people at NSF to devise a plan to support efforts to energize the engineering education process, including increasing the pipeline and the image of engineering to the general public.

4. That NSF be urged to capitalize on the huge efforts and money that went into the ERC Education Coalitions that are no longer functional and to urge the use of best practices discovered by them.

5. That the ASEE section and national conference organizers support the most important issues facing our enterprise through the judicious allocation of plenary sessions, invited sessions, and open sessions each and every year. Indeed, an analysis of the data presented in Appendix A suggests that several high-ranking major topics (identified in bold) can be isolated for further discussion.

6. That the BOD designate each year as dealing with a special topic and doing a follow-up report that represents the best thinking with respect to that aspect of engineering education.

7. That the ASEE sections be encouraged to have a specific session/panel/speaker on K-12 issues, and invite local STEM teachers and pupils to come as guests to this session.

YOD Follow-Up and EEGE

The most important part of YOD was not discussion or consolidation of the topics, but instead is the follow-up that takes place. This requires a firm commitment on the part of ASEE members that often is lacking in the initiatives of other groups or committees in the past, such as the NAE 2020 reports[5,6]. Indeed, ASEE has recently initiated action concomitant with the YOD. Called "Engineering Education for a Global Economy" (EEGE)[7], this initiative is critically examining five aspects of engineering education:

1. Scholarly educational practice.
2. Engineering education research.
3. Faculty preparation and development.
4. Internal contexts.
5. External contexts.

EEGE is an effort by ASEE membership to focus on the "Scholarship of Engineering Teaching" in order to reform Engineering Education in America and to produce engineering graduates who are prepared for the rigorous, global challenges of the 21st Century. Fundamental reform is needed in the way engineering educators teach classes to the current generation of students. Engineering faculty can participate in EEGE by doing one or more of the following things promoted by ASEE:

1. Adopt one or more "best practices" for engineering teaching that are presented in an ASEE brochure, including assessment strategies.
2. Consider participating in the ASEE Engineering Teaching Certificate Program that is being discussed for implementation.
3. Get involved in the "Engineering Educational Research" (EER) community, and participate in EER activities, such as some of the opportunities/resources mentioned in an ASEE brochure.

Best Practices in Engineering Teaching

The EEGE project calls for ASEE to identify the "best practices" in engineering teaching and to disseminate these best practices widely. For each best practice, there should be a short definition or description of the best practice and how it can be implemented in the classroom. The implementation should also include a common assessment tool to be used with the practice. Some examples of possible "Best Practices" in Engineering Education could include:

1. Project-Based, Problem-Based, Challenge-Based Learning.
2. Active and Interactive Learning, Hands-On Learning.
3. Multi-media Videos and Computer Simulations.
4. Tablet PC with Projection System.
5. Socratic Dialog and Group Discussions.
6. Internet and Asynchronous Learning Sites.
7. Webcasts, Podcasts, Social Networking, Twitter Lectures.
8. Team Projects, Service Learning, Self-Directed Learning.

For each of the above, several citations should be included that most-strongly support use of the best practice and that serve as look-up references for faculty to further study the practice.

The ASEE Teaching Certificate Program

It has been proposed that ASEE sponsor a "Teaching Certificate" program. Based on evidence supplied by the faculty member, that faculty could qualify for and achieve a certain level of engineering teaching competency. Such achievement could be positively used, for example, in promotion and tenure deliberations, post-tenure review, on annual faculty reports, job resumes, and other types of evaluation. There is also some thinking that, attainment of an Engineering Teaching Certificate by key faculty leaders in a department, would help satisfy ABET Criterion 6, which relates to the collective faculty competencies of the department. There are still details about the program that ASEE must work out, including financial encumbrances. However, some thought has already been given to the levels of teaching competencies, as shown in Table 3.

Table 3. Four Levels of Engineering Teaching

1. Excellent Engineering Teacher • Has excellent content pedagogy • Receptive to and concerned with student learning • Receives excellent student ratings
2. Scholarly Engineering Teacher • Is a (1) Excellent Engineering Teacher • Collects class data and other information to assess student learning • Uses this data to continuously improve the course
3. Scholar of Engineering Teaching • Is a (2) Scholarly Engineering Teacher • Shares learning and assessment findings with the EER community through presentations, conference proceedings, and journal publications • Receptive to feedback from EER community

4. Engineering Educational Researcher

- Is a (3) Scholar of Engineering Teaching
- Develops original theories and models of engineering student learning
- Publishes original findings in leading engineering education journals
- Is a member of the EER community

The ASEE Engineering Education Research (EER) Community

Part of the EEGE project objectives is to define and promote the concept of an "Engineering Education Research" (EER) community. Who constitutes this EER community and how does one become a member of EER, is still not well-defined by ASEE. Nonetheless, there are components of the community that can be currently identified. Certainly there are already a number of nationally-known, master engineering teachers that can be inaugural "grandfathered" members. There are also many resources and opportunities for participation: publication opportunities in the *Journal of Engineering Education*, education-related conferences such as *Frontiers in Education (FIE),* and special engineering education centers and departments.

The above EEGE project is being formulated during meetings in 2008 and 2009, and plans for implementation of action items, in the form of a report, will be available for the ASEE Annual Conference in June 2009. So, there is still much discussion remaining for the EEGE project and the ASEE membership will have more opportunities for input after the first report is distributed.

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Appendix A

Table A.1. Consolidated Data for Category A (Faculty Issues and Rewards)

Topic	St. L	NE	MA	SE	NC	Il/In	NMW	MW	GSW	RM	PNW	PSW	ETLI	Total (√)	Category
1. Consider Educational Research in Promotion and Tenure	√		√			√	√		√	√	√	√	√	**9**	**A**
8. Seek Input and Support from the Engineering Deans	√		√		√	√	√		√	√			√	**8**	**A**
35. Small Teaching Schools versus Large Research Schools.				√			√		√		√	√		5	**A**
12. Create Different Pathways for Faculty Promotion and Tenure	√		√			√							√	4	**A**
37. Increase Faculty Rewards						√	√		√					3	**A**
39. Provide Early Mentoring						√	√		√					3	**A**
27. Engage Research Faculty in Undergraduate Teaching					√		√							2	**A**
41. Teach Graduate Students How to Teach											√	√		2	**A**
36. Provide Continuing Ed Credits						√								1	**A**
40. Change Culture at Conferences						√								1	**A**

Table A.2. Consolidated Data for Category B (Pre-College K-12 and Outreach Issues)

Topic	St. L	NE	MA	SE	NC	Il/In	NMW	MW	GSW	RM	PNW	PSW	ETLI	Total (√)	Category
21. K-12 STEM Education and Engineering Student Recruitment.		√		√		√			√	√		√	√	**7**	**B**
31. Focus on Early Science and Math Course Improvements.											√	√		2	**B**
23. Summer Engineering and Science Camps for Students		√												1	**B**
33. Modern Students Grew-Up in a "Video Gaming" Environment.										√				1	**B**
38. Develop Outreach Programs						√								1	**B**
42. Address Diversity Issues									√					1	**B**

Table A.3. Consolidated Data for Category C (Curriculum Reform and Evaluation Issues)															
Topic	**St .L**	**N E**	**M A**	**SE**	**N C**	**Il/ In**	**N M W**	**M W**	**G S W**	**R M**	**P N W**	**P S W**	**ET L I**	**To-tal (√)**	**Cate-gory**
9. ASEE Should Compile and Promote Best Teaching Practices	√				√		√		√	√	√	√	√	**8**	**C**
6. Discussed ABET Standards and Influence			√		√	√	√							4	**C**
22. Try Active Learning, Hands-on, Project-based, Adaptive Teaching, etc.		√			√					√			√	4	**C**
24. Establish Engineering Assessment Measures for Teaching	√		√			√						√		4	**C**
10. Discuss Body of Knowledge for Engineering Education	√		√											2	**C**
15. Teach Creativity and Innovation			√											1	**C**
28. Teach Lifelong Learning				√										1	**C**
30. Have a General BA in Engineering				√										1	**C**
32. Include Communication and Multi-cultural Skills.										√				1	**C**

Table A.4. Consolidated Data for Category D (Outside Resources and Influences)															
Topic	**St .L**	**N E**	**M A**	**SE**	**N C**	**Il/ In**	**N M W**	**M W**	**G S W**	**R M**	**P N W**	**P S W**	**ET L I**	**To-tal (√)**	**Cate-gory**
5. Seek Industry Input on SEE					√	√	√	√			√		√	**6**	**D**
2. Discussion of "Rising Above the Gathering Storm"			√		√			√	√	√				5	**D**
17. Think Globally, Educate Global Engineers			√			√		√		√	√			5	**D**
3. Discussion of the "Engineer of 2020" Report			√		√			√	√					4	**D**
4. Discussion on Socratic Dialog in Chicago		√	√			√			√					4	**D**
19. ASEE Should Produce a Report on SEE	√							√						2	**D**
29. Promote Engineering Careers to the American Public				√					√					2	**D**
25. What was the Influence of Recent NSF Coalitions on Engineering Education					√									1	**D**

Table A.5. Consolidated Data for Category E (Research Topics and Issues)															
Topic	**St .L**	**N E**	**M A**	**SE**	**N C**	**Il/ In**	**N M W**	**M W**	**G S W**	**R M**	**P N W**	**PS W**	**ET L I**	**To-tal (√)**	**Cate -gory**
18. SEE has Many Aspects Besides Rigorous Educational Research	√	√	√				√	√	√	√	√			**8**	**E**
7. Compared Educational Research to Technical Research	√		√	√			√	√	√		√			**7**	**E**
11. Seek Opportunities to Publish Papers in JEE and AEE			√			√	√	√	√		√	√		**7**	**E**
14. Partner with Social Scientists and Learning Scientists			√	√			√		√			√		5	**E**
16. Study "How People Learn" and Learning Styles			√				√				√	√	√	5	**E**
13. ASEE Should Create More Short Courses, Teaching Seminars, Educational Research Sessions	√				√	√				√				4	**E**
20. Look at Chemistry and Physics Education for examples			√								√			2	**E**
26. Track the Development and Success of New Engineering Education Programs					√						√			2	**E**
34. Increased Focus on Research Because of State Funding Cuts									√			√		2	**E**