

Advancing Global Capacity for Engineering Education Research: Preliminary Findings

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Abstract - Advancing the Global Capacity for Engineering Education Research (AGCEER) is a joint initiative by the *European Journal of Engineering Education* (EJEE) and the *Journal of Engineering Education* (JEE). The purpose is to significantly advance the global capacity for engineering education research. A series of moderated interactive sessions are being offered at international engineering education conferences between July 2007 and December 2008. In these sessions, participants discuss what constitutes engineering education research, who is and should be involved, and what infrastructure is required to sustain engineering education research. To date, AGCEER sessions have been held at regional engineering education conferences in Europe, Hong Kong, Australasia, and at the ASEE Global Colloquium in Turkey. Future sessions are planned for Europe, the United States, Russia, Brazil, South Africa, and India. Transcripts of completed sessions were analyzed using qualitative, open coding methods. Common themes across all these sessions were (a) the need for more rigorous engineering education research, (b) improving resources and recognition for engineering education researchers, and (c) getting research results into the hands of practitioners. Variations across countries and regions include who is engaged in engineering education research (e.g., faculty, administrators, policymakers), their levels of activity, and their interest and expertise in engineering education research. Our analysis includes some background on engineering education in each of these regions to help explain variations in the current state of research efforts.

Index Terms – conference, engineering education research, global, research capacity

INTRODUCTION

Due in part to significant recent investments in the reform of engineering education (e.g., [1]), “globally, engineering education development is a more mature field in comparison to engineering education research which is still in its infancy, both in terms of its philosophical structure and physical infrastructure” [2]. As “[t]he vitality of any discipline depends on a vibrant community of scholars and practitioners advancing the frontiers of knowledge through research and innovation,” [2] these are the markers of the extent to which engineering education research is and should be developing as a discipline [3, 4]. The number of regional and international conferences and journals focused on

engineering education attests to increasing interest in engineering education research. However, little is known about the field’s state of development, and the associated research areas being pursued, in different countries and regions. Without this knowledge, opportunities for collaboration in the international engineering education community are limited. The first research question guiding our studies is: How do engineering education researchers and practitioners in different countries and regions conceive of the nature of engineering education research, important areas of inquiry, its relationship to other scholarship, and its supporting infrastructures? This conference paper reports preliminary results using data collected at conference special sessions on global engineering education research (EER) capacity.

METHODS

I. Setting: Advancing Global Capacity for Engineering Education Research

Advancing the Global Capacity for Engineering Education Research (AGCEER) is a joint initiative by the *European Journal of Engineering Education* (EJEE) and the *Journal of Engineering Education* (JEE). It has four goals, including:

- build a network among the community of scholars and practitioners who participate in the AGCEER sessions, &
- identify the critical infrastructure needed to encourage and sustain a global community of researchers and practitioners in engineering education research.

II. Data Collection

Table 1 lists the conferences at which the first four AGCEER sessions were held, as well as some characteristics of the participants. Each session featured two to four invited guest speakers who commented for 10-20 minutes on a topic related to global engineering education research capacity [2]. In groups of four to six, participants then discussed questions related to the nature of engineering education research, important research questions or areas, and types of available support. Questions were updated for each session in response to the outcome of the previous session. The questions as worded for the Australasian session were:

1. “What makes engineering education research different from other forms of innovation in engineering education?” (Is it the problems studied? The methods and approach employed? The knowledge base needed? The qualifications of the researchers? ...)

2. “What structures and mechanisms already encourage and support engineering education researchers, and which other ones need to be created and implemented?” (For example, academic departments, research centers, funding, research journals, professional societies, research conferences,...?)
3. “If AaeE [the professional society hosting this conference] were to create a special interest group for Educational Research Methods, what should be the focus of its activities and/or services?”

The third question was included at the European session, but not at the other two. European participants self-selected groups to discuss only one of the questions; other participants discussed all questions but reported back on only one as time allowed.

Session organizers made audio recordings of the report back portions and collected note pages from each group. Human subjects (IRB) approval was secured to use these as data sources, provided that the initial presentation included an explanation of the procedures. Presentation slides and general observations at other conference sessions also served as a data sources.

III. Data Analysis

Although the transcript data are qualitative, their depth is limited by time constraints on the sessions (most of which were under two hours). We applied a limited open coding procedure to identify issues raised in each of the sessions.

RESULTS

Table 2 lists the codes and identifies at which AGCEER sessions they were mentioned either in audio recordings or on note sheets. Though the level of detail varies, there were a number of common themes which emerged from the sessions.

I. Distinguishing Engineering Education Research from other forms of Engineering Education Scholarship

Regarding what distinguishes engineering education research (EER) from other forms of scholarship, there was much agreement, although levels of specificity varied. As

listed in Table 2, participants reported that EER is different from educational research because of the engineering setting, and that EER is different from innovation and curriculum development activities because it is “more rigorous.” Additionally, one group in Hong Kong articulated that research creates something new, as opposed to merely applying it. In some cases, participants elaborated on definitions of rigor, listing: well-defined questions or problems, use of theory, and answering broader (less localized) questions. Many pointed out that IRB or ethics clearance is needed for research, and participants at the Australasian session stated that this was particularly difficult due to regional policies.

Within the Hong Kong session, the two speakers argued that what little EER is being done in East Asia is not necessarily being recognized as such. Based on the results of a survey of engineering deans, one speaker described the current status of engineering education research in Hong Kong as “non-existing,” adding that engineering education research is “not a commonly used term in Hong Kong” as well as “an area being ignored right now in Hong Kong.” Similarly, the other speaker showed a long-standing lack of research-oriented evaluation papers published in the *Chinese Journal of Engineering Education*, as well as a growing number of paper authors who are administrative staff or from the field of education (as opposed to engineering). Accordingly, Hong Kong session participants were decidedly skeptical about the usefulness and future of EER. One explained during report back:

[I]n order to be encouraged and supported, we felt that work of this sort has to *deserve* encouragement and support. And in order for that to be the case, such researchers would have to be credible in the context of comparability alongside more traditional research. Therefore, they must enhance each institution's reputation, and they must either produce, or have the potential to produce, real benefits.

Another participant elaborated, “The research is about actually measuring the effectiveness of those innovations in a scientific way.” We observe that skepticism and outcomes-based assessment are recurring themes in East Asian EER.

TABLE 1
CONFERENCE SESSIONS AND PARTICIPANTS

CONFERENCE, DATE, LOCATION	CONFERENCE ORGANIZERS	AGCEER PARTICIPANTS
1 st SEFI-IGIP Joint Annual Conference, 1-4 July 2007, Miskolc, Hungary	Société Européenne pour la Formation des Ingénieurs, and Internationale Gesellschaft für Ingenieurpädagogik	21 Attendees (100% from Europe), 4 Speakers (Europe and US), and 2 Journal Representatives
6 th Global Colloquium on Engineering Education, 1-4 October 2007, Istanbul, Turkey	American Society for Engineering Education, Boğaziçi University, and the Turkish Engineering Deans Council	45 Attendees (60% from US), 2 Speakers (US and Canada), and 2 Journal Representatives
1 st International Forum on Engineering Higher Education, 8-10 November 2007, Hong Kong, China	Hong Kong Polytechnic University and Zhejiang University, China	37 Attendees (86% from China, Hong Kong, Taiwan or Japan), 2 Speakers (Hong Kong and China), and 1 Journal Representative
2007 Australasian Association of Engineering Education Conference, 9-12 December 2007, Melbourne, Australia	Australasian Association of Engineering Education	21 Participants (95% from Australia or New Zealand), 2 Speakers, and 1 Journal Representative

TABLE 2
SUMMARY OF RESPONSES

CATEGORY (~QUESTION) CODE (RESPONSE)	EUROPE (HUNGARY)	GLOBAL (TURKEY)	EAST ASIA (HONG KONG)	AUSTRALASIA (AUSTRALIA)
DISTINGUISHING EER FROM OTHER FORMS OF EE SCHOLARSHIP				
Engineering setting	X	X	X	X
More rigorous methods (general)	X	X*	X*	X
Common language across engr and ed	X	X	X	X
Inter/multidisciplinary expertise	X	X	X	X
Use of theory		X	X	X
Clearly defined questions	X	X		X
Both quantitative and qualitative methods	X	X		
Higher-level, more complex problems	X			X
IRB required, ethics		X		X
Creates new knowledge, doesn't just apply it			X	
WHO SHOULD DO EER				
Include education and social science researchers	X	X	X	X
Include more engineering faculty	X	X	X	
General comments about inclusivity, openness		X		
SUPPORT STRUCTURES – RESEARCH				
Funding	X	X	X	X
Support of administrators	X	X	X	X
Legitimization and recognition as a discipline or specialty research area	X	X		X
Reward system – value EER more		X		X
Career path for EE researchers, e.g. faculty positions		X	X	
Professional societies, ERM group, critical mass	X	X		X
Conferences	X	X		X
EER awards and fellowships		X	X	
Connecting engineers with education/SS researchers			X	X
Mentoring		X		X
Case studies of how to do EER				X
Training for researchers (workshops, fellowships)		X		X
Train future faculty while still graduate students			X	
Research centers		X	X	
SUPPORT STRUCTURES – IMPACTING TEACHING PRACTICE				
Training for faculty, “staff development”	X	X		X
Teaching centers	X	X	X	
Reward system – value teaching more		X		
Accessible knowledge base (bibliography, summaries on web site)	X	X		X
Disseminating results and impacting practice	X	X		
Cyclic relationship of research and practice		X		X
More inclusive journal(s) reporting on practice		X		X

*To some groups, this meant controlled experiments.

The only identified area of disagreement regarding this question was with respect to quantitative and qualitative methods. Statements at the European and Global Colloquium sessions (made by non-US groups) were inclusive of both quantitative and qualitative approaches. However, an all-US group at the Global Colloquium session favored experiments and hypothesis testing (which were listed several times on their form), in addition to the “need to work on objectivity, rigor, reliability[,] replicability.” There were also Hong Kong participants who focused on systematic investigations such as controlled experiments.

II. Qualifications and Characteristics of Engineering Education Researchers

“Who should be doing EER and what qualifications are necessary” was a subquestion addressed in all four sessions. This is one area in which there are observable regional

variations. In all sessions there were individuals and groups who asserted the importance of involving (a) faculty for the purpose of impacting practice or (b) involving education and other social science researchers. However, groups appeared to advocate for one or the other but not both. The relative balance of interdisciplinary research expertise (educational researchers) and impacting practice (engineering faculty) at each conference was notably different. Australasians focused their discussions on building expertise for EER and locating education and other social science researchers with whom to collaborate. They hinted at times that the literature should be made more “accessible;” however, it was not emphasized whether this was for novice researchers, and/or teachers. At the European session, the group discussing the same subquestion made statements about broad inclusivity of researchers, stating

We really didn't want to name anyone in particular. We liked that there was a variety of people who are engaged in this currently. That there are teachers and there are researchers and policy people involved in the situation and also the multidisciplinary approach, that there are people from many different disciplines and that they fit together.

The group discussing infrastructure was more focused on "staff development" (or what Americans refer to as faculty development).

Throughout the Hong Kong session, there was a clear message that administrators are the ones currently involved in EER as well as the leaders who will signal to others when EER is accepted. As noted previously, faculty participants were waiting for convincing evidence and support of administrators before committing to EER.

At the Global Colloquium, there was again less agreement than at other sessions. Many of the groups discussed faculty development activities and rewards for teaching excellence, and one strongly advocated for partnership with engineering disciplinary societies. Both of these approaches were unique to this session. There were two groups whose responses represented two extremes. One group (with no US members) that emphasized education theories and methods, and then wrote, "Community of researchers...do not currently seem to reflect this broader education research discourse." This first group did not mention faculty (as distinguished from researchers) anywhere in their responses. This lies in sharp contrast to another group (5 of 6 American) at the same session that reported,

[W]e believed that there should be strong ties between researchers and practitioners and there is a danger of elitism if that's not contained. We said whether or not we actually need separate departments of engineering education on campuses, that's not clear to us.

On this group's report back sheet, there was mention of "interdisciplinary work" and the need to recognize and reward it. Apparently this group felt that EER must take place within traditional engineering disciplines. It should be noted that, among the participants at this session, there were at least five faculty and students from US departments of engineering education, and their groups cited issues such as career paths for engineering education researchers. We suspect that some of these comments about elitism were directed at them.

On a related note, there was general mention of inclusiveness or openness in the field. In general, participants at the various sessions want engineering education to be a friendly, constructive community, with more activities to facilitate networking. One group criticized specific aspects they felt were not open enough. This group, which was quoted earlier in this section, elaborated on a view of EER as "an oasis that will attract others rather than a castle surrounded by a protective moat."

III. Support for Research

We observed strongest agreement—and strongest emotional response—to questions about infrastructures for EER. It was clear that many European, Australasian and American participants, naturally attracted to these sessions by their interest in EER, felt they were not supported at their home institutions in pursuing EER. Emotional response was strongest at the Australasian and Global Colloquium sessions. Most frequent responses across all sessions included: more funding, more prestigious funding (Australasia), support from administrators in the form of understanding the work and providing resources for it, valuing EER as legitimate research for promotion and tenure, and more general recognition as a research field. Uniquely at the Hong Kong session, there was evidence of a strong top-down approach in which faculty were waiting for administrators to value EER and direct resources to it. Explanations like, "The top-down approach may be the best way. Let the president of university or dean of engineering feel that engineering education is important. So they are willing to support these activities." were typical in this session. However, indicators that EER was being accepted were similar at all four events (Table 2).

Other responses were also more specific to the local context. Europeans spoke more generally about the need to combine smaller studies and enclaves of researchers, an argument first put forth by one of the speakers. Australasians were more explicitly trying to develop an Educational Research Methods (ERM) division in the AaeE, so the responses cover a range of professional society activities regarding education and networking (Table 2). (SEFI leaders also viewed the AGCEER session as an opportunity for forming an ERM group, but their session was less focused on exactly what such a group should undertake.) Participants at the Global Colloquium were less focused on mobilizing themselves, and, rather, called for more conferences, journals, and reforms to the reward system for faculty. On one hand, we might expect this result because the other conferences were organized by regional professional societies, while the Global Colloquium was intentionally a more international mix of participants less aligned with a specific division of ASEE. On the other hand, focusing on solutions that participants themselves are not empowered to change, and those that are particularly difficult for anyone to change (e.g., deeply entrenched faculty reward systems), is not particularly constructive discourse. Finally, it is not clear whether this dynamic emerged because of the diversity of participants or the large number of US participants. We return to this point below.

IV. Impacting Teaching Practice

To varying degrees, participants listed different support structures for impacting teaching practice, including disseminating research results. European and Australasian participants only touched on these points as part of a more holistic understanding of the field, whereby research informs practice. The European session included discussion (in two different groups) of informing policy decisions with

research results and training engineering faculty in pedagogical methods. As stated earlier, it was not clear whether “accessibility of results” was cited at the Australasian session for practitioners or researchers (perhaps both). In both cases, participants appeared to have an especially nuanced view of how research, practice and policy complement and inform one another. Participants at the Australasian session spent time describing the cyclical relationship between engineering education research and practice. (This was also listed by one American group at the Global Colloquium and present on one of the speaker’s slides.) Comments from Hong Kong participants were vaguer, but touched on the importance of working across disciplinary, research-practice, and administrator-faculty boundaries. Overall, participants in the Global Colloquium session were concerned with rewards for teaching (as they were with rewards for research). Additionally, one group (all US members) strongly advocated working through engineering disciplinary professional societies for disseminating results at conferences and in journals, as well as sponsoring more teaching awards.

V. Important Research Areas

One of our research questions, as well as an embedded question for participants, was “Important areas for EER to investigate.” In general, participants were too overwhelmed with other questions and a limited time frame to address this in depth. The European session featured a guest speaker describing the Research Agenda for EER [5], and as might be expected, the idea of an agenda was discussed more explicitly at this session. Two of the three groups acknowledged that an agenda would help focus efforts and that the one offered was “a good starting point.” At the Global Colloquium, several groups at least hinted at research areas, including: “teaching styles and issues,” “recruitment and retention,” “raising and keeping interest in engineering,” and how to teach engineering processes such as design. Only one group spent time in their report back on this issue, by stating that the overarching question of EER is, “How do we better educate better engineers?” At the Hong Kong session, one group questioned, “Is the product here a better teacher or a better engineering student, a better engineer?” Others at this session listed motivation, learning styles, measuring creativity, and comparing 3-year to 4-year degree programs.

Given time constraints and the multitude of other issues to discuss, the AGCEER sessions are not a particularly rich data source for which EER areas are considered important in various regions. As our work moves forward, we will address this research question mainly through keyword analysis of papers from around the world published in engineering education conference proceedings and journals.

DISCUSSION

We can better understand the responses given at each session by placing them in the context of engineering education in each region.

In Europe, the Bologna Declaration and so-called “Dublin Descriptors” are building consensus around, and stimulating research on, common competencies which would facilitate transfer of students, faculty and coursework throughout the EU. This type of alignment and standardization was an important topic of discussion at the SEFI-IGIP conference, which was carried through one of the AGCEER speaker’s talks and subsequent group discussion at the session. The types of boundaries Europeans seem concerned about crossing at this point are national (within the EU). While there was some mention that researchers and policymakers should work together more often, disciplinary boundaries do not appear to be a critical barrier to EER in this region. The US observer who attended this conference was struck by the interdisciplinary backgrounds of many conference attendees, who completed education training by studying engineering settings and remained active members of the community through their work and professional organization affiliation.

At the Australasian AaeE conference, participants were open and proactive in looking to the US and UK for leadership. Although the conference itself had only 100 participants, most from Australia and New Zealand, there were a number of keynote speakers and workshop presenters from Europe, the US and Australia. One of the keynotes presented preliminary results on a study of the Australian engineering accreditation criteria, which are closely aligned to US ABET EC2000 criteria and adopted around the same time. An overarching theme at the conference was the changing nature of engineering as it becomes more focused on communication, collaboration, management, interdisciplinary, and sustainability skills to be fostered by more authentic projects and applications. As such, the responses of Australasians at the AGCEER session are similar to both American and European responses. Emphasis on institutional rewards, specifically a lack of recognition for EER, is also a characteristic American response in discussions of EER. However, less rigidly structured views of disciplines and research-to-practice are more similar to the European views described above.

As compared to other events, discussions at the Hong Kong forum were characterized by a lack of both breadth and depth. Participant presentations and comments were often focused on assessment in engineering education, leaving other research and reform topics under-explored. This was especially evident among Hong Kong participants, likely due to: a) well-established accreditation criteria for engineering degree programs, b) status as a signatory of the Washington Accord, and c) current transition from 3- to 4-year degrees. In China, on the other hand, discussions were tilted by unique challenges related to: coordinating large numbers of schools; developing accreditation criteria and processes for engineering programs; and updating outdated content and teaching methods. The observed deferential attitude of faculty toward engineering education leaders and administrators is also likely linked to cultural considerations in the East Asian context. An emphasis on hierarchy and

group over individualism, for example, may lead faculty to defer to their higher-ranking colleagues when asked to publicly comment about the state and trajectory of EER.

Regarding the wide range of responses at the Global Colloquium session, there are two competing explanations. First, the majority of participants (60%) were from US institutions. Second, the conference was not sponsored by a regional professional society at a location in that region and global participation was an explicit goal. In short, the broad range is attributable to the mixing, but we can still extract dominant US attitudes toward EER from responses. Most of the extremes cited above were reflected in differences between a US and a non-US group's responses.

We propose that the characteristic American views of EER we observed are closely related to rigid disciplinary and departmental structures. Summarizing a comparative analysis of higher education structures in the US and Europe, in which he found the US to be particularly rigid, Andrew Abbott explains, "The American system of disciplines thus seems uniquely powerful and powerfully unique" [6]. This is demonstrated through the support structures cited by US participants, which are more organizationally driven than those cited by others. For example, recognition for EER and disseminating results of EER to teaching practitioners were concerns arising in every session. But US groups at the Global Colloquium cited more examples of structural or organizational rewards (e.g., awards and fellowships, particularly for teaching) than others. Australasians were just as frustrated that their EER work was not being appreciated, but were more likely to desire understanding and legitimization from others than specific structural support like awards (though funding was important to everyone). Similarly, Europeans at SEFI-IGIP and the Global Colloquium called for more "staff development" and "subject centres" (similar to engineering teaching and learning centers in the US) to improve teaching, whereas US participants were more specific about structural incentives to improve teaching, e.g., teaching awards, promotion and tenure considerations around teaching, and practice-focused journals.

US participants were also more concerned with disciplinary structures such as departments and professional societies. Across all sessions, participants stated that education knowledge, theories and expertise are important to EER. US participants were most explicit about how to (and how not to) access and reward this expertise. Australasian engineers were clear about the desired role of their new ERM group to facilitate networking with educational researchers, but again structural rewards for collaboration were not discussed. At the Global Colloquium, one US group felt strongly that departments of engineering education are inappropriate because the work should be done within traditional engineering departments and rewarded as legitimate interdisciplinary work. In other conference settings [3], proponents of these departments cited stability and recognition as motivations, and this is reflected in the responses of some US AGCEER groups.

The rigid departmental structure characteristic of US higher education plays into dissemination, as well as recognition, for EER. Regarding dissemination, some US participants are concerned that EER results will only be useful or used if they are created in traditional engineering settings. Regarding recognition (as well as quality issues and "rigor"), other US participants feel that establishing departments as a marker of discipline development is the only sustainable or successful model. The tension lies in the perceived incompatibility of these two approaches.

Of course, the sample size and short session lengths limit our ability to draw generalized conclusions. However, there is evidence that the results of these first four AGCEER sessions triangulate with the results of related studies. Future sessions, such as those in Brazil and South Africa will provide a more complete picture. This paper provides some initial analysis to push the EER dialog forward, as well as hypotheses to explore in our future investigations.

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