
AC 2011-452: RIGOROUS EDUCATIONAL RESEARCH IN CIVIL ENGINEERING:

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Rigorous Educational Research in Civil Engineering: What Does it Look Like and How are We Doing?

Abstract

This document evaluates the quality of papers accepted to the American Society for Engineering Education (ASEE) annual conference by the ASEE Civil Engineering (CE) Division during the past four years (2007-2010) with respect to high quality rigorous research as accepted by the academic and/or professional communities. In total, the complete manuscript for 265 papers accepted to the Civil Engineering Division were reviewed and analyzed relative to a categorization of accepted standards for educational research. The results showed that the vast majority of the papers accepted by the CE Division failed to meet one or more aspects of accepted research standards. Trends in the research standards represented in papers accepted by the Division have also been identified. Understanding the Civil Engineering Division's current level of rigor in scholarly research is useful for establishing and holding the CE Division to measured and progressively higher standards that are necessary to improve civil engineering education.

Introduction

Consider for a moment what steps you would use in the performance of engineering research within your discipline of expertise. Perhaps such things as a clearly formulated hypothesis, a strong grounding in the related literature, a defined methodology, and a concern for validity and reliability come to mind as expectations within your field of practice. A minimum level of scholarship is expected in the performance of research in all engineering disciplines. An individual undertaking serious research would not attempt to publish a technical manuscript in a journal or present findings at a conference without meeting the rigorous expectations as established by the academic community. Then why is it that these commonly understood rigorous standards are so often overlooked when conducting educational research? Educational research, when performed properly, is a form of technical research; therefore, it can and should be conducted in a rigorous manner.

During the past 5 years, there has been a widespread call for increased quality and rigor in the performance of engineering education research (Melsa, 2007; Shavelson & Towne, 2002; Streveler & Smith, 2006; Watson, 2009). For at least the past three years, the Executive Board of the Civil Engineering (CE) Division of the American Society for Engineering Education (ASEE) has discussed the desire to "raise the bar" on the level of scholarly education research. Specifically, the Executive Board has expressed an interest in seeing an improvement in the scholarship contained within the papers accepted by the Division to the annual conference. The mission statement of the CE Division affirms that the organization's purpose "shall be the advancement of civil engineering education in all of its functions which pertain to engineering and allied branches of science and technology, including the processes of teaching and learning, counseling, research, extension services and public relations" (American Society for Engineering Education, 2010d). Thus, to advance civil engineering education research, we must have an understanding of our current level of research achievement relative to established standards.

In order to understand our current level of research achievement, the authors posed the following research question in performance of this study: “What level of rigorous educational research is represented in the ASEE Civil Engineering Division papers accepted to the annual conference over the past four years?” The authors were motivated to undertake this study by a desire to recognize the current state of scholarship in the CE Division’s educational research and to contribute to the potential improvement thereof. This manuscript includes a discussion of what constitutes rigorous educational research and will attempt to model performance of such scholarship.

Literature Review

It is not unusual for academic communities to occasionally self-assess their collective ability to meet established research standards. Such assessment is commonly performed through a review of the publication(s) associated with that field of practice. By evaluating multiple years of publication, the caliber of research can also be evaluated for trends. Several examples of such self-assessment studies have been performed in the field of engineering education. This literature review is subdivided into three sections: example studies of scholarship, suggested scholarship standards, and description of scholarship standards.

Example Studies of Scholarship

Wankat (1999) published the results from a critical review of 20 issues of the Journal of Engineering Education (JEE). His review included 231 articles published in JEE between 1993 and 1997. Wankat’s study was later updated to include a total of 597 articles over a ten year period (Wankat, 2004). Revision to the original study permitted comparisons of the level of scholarship between the publications in the first five and second five years. Whitin & Sheppard (2004) conducted a similar study of 398 articles contained in 25 issues of JEE published between 1996 and 2001. Borrego (2007) reviewed the abstracts of 700 peer reviewed journal articles and conference papers generated between 1990 and 2005 by the National Science Foundation sponsored engineering education coalitions.

In each of these studies, scholarship was assessed using well-defined parameters that were unique to the study. For example, Wankat (1999) specifically evaluated the number of “usable” references per article. He reported that the average number of “usable” references in JEE articles was 15.2 between 1993 and 1997 and defined “usable” as the “number of unique references which could probably be obtained by the reader.” In addition, Wankat (1999; 2004) also looked at the inclusion of assessment methods as an indication of scholarly education research and reported that during the first five years only 44% the articles had some form of assessment, while during the second five years, 60.2% of the articles had some form of assessment. This would suggest an increase in the level of research rigor during the limits of the study from the perspective of that criterion. Olds, Moskal, & Miller state that “high-quality assessment can provide educators with information they can use to move the field forward” (Olds, Moskal, & Miller, 2005). Thus, the use of assessment as a measure of research rigor would seem appropriate.

Whiten & Sheppard (2004) defined their criteria for a scholarly article to include research with a well-defined goal or thesis and executed in a manner consistent with other forms of scholarly research. Further, they stated that scholarly presentation of research must include a topical and timely subject matter whose impact is felt beyond the immediate future, and includes convincing data and evidence rather than anecdotal accounts. Whiten & Sheppard reported that there was a significant increase in the number of JEE articles that included the required characteristics, but due to the subjective nature of assessing scholarship, they did not report specific numbers.

Borrego's (2007) study evaluated the principal group being studied, the nature of the intervention, and the manner in which possible change was communicated. Overall, Borrego reported that 74% of the abstracts she reviewed were classified as "experiences." Such manuscripts lacked a research question and commonly just reported the experiences of the author(s) or tell the story of a newly implemented program. Over the limits of Borrego's study (1990-2005) the number of "experiences" manuscripts declined, while the number of research papers was on the rise.

Suggested Scholarship Standards

In a call for continuous improvement in the scholarship of engineering education research, Streveler & Smith (2006) define rigorous research using the guidelines provided by the National Research Council (NRC). The NRC has published a report titled *Scientific Research in Education* (Shavelson & Towne, 2002). That report states that rigorous research in education should address the following guiding principles:

1. Pose significant questions that can be answered empirically
2. Link research to relevant theory
3. Use methods that permit direct investigation of the question
4. Provide a coherent and explicit chain of reasoning
5. Replicate and generalize across studies
6. Disclose research to encourage professional scrutiny and critique

Streveler & Smith note that the NRC guidelines "parallel the criteria for rigorous research in engineering and science" and should therefore be "familiar to engineering educators" (2006). A study conducted by Borrego, Streveler, Miller, & Smith (2008) asked a group of engineering educators to define the criteria for rigorous research in their respective engineering disciplines. The results reported by Borrego et al. show a striking similarity between the list of engineering research criteria and the guiding principles for rigorous educational research provided by the NRC. As part of that same study, Borrego et al. suggested that the term "rigorous" involves value judgment. They generated a comparative organizer as shown in Table 1. This generalization of scholarly research into two categories, "informal research" and "formal research" may be an oversimplification, but it does provide an efficient means to evaluate educational research. Within Table 1, examples of "informal" and "formal" aspects of hypothetical research projects are provided for various portions (categories) of a typical research project. It is not suggested that research must be performed fully within the realm of "formal" to achieve "formal" status. Further, it should be noted that there is very clear value associated with "informal research." Borrego et al., as well as the authors of the current study, are not

suggesting that there is no value or no need for “informal research.” Rather, “informal research” has limitations and must be recognized as such.

Table 1. Informal vs. Formal Engineering Education Research
(reproduced figure 2 from Borrego et al. (2008))

Category	Informal Research	Formal Research
Motivation and purpose (what will the results be used for?)	Improve teaching and learning in my class	Identify basic processes of understanding including common misconceptions held by different learners
Question to be answered	Why don't my students remember how to use material from their pre-requisite course?	What misconceptions arise as students learn about it and attempt to apply it?
Use of the education research literature	Teaching practice literature from books and articles used to inform thinking about classroom approaches	Evidence-based literature from education (including engineering education) to explore relevant theories and use theoretical frameworks to design study and explain results
Feedback sought and given with colleagues	Informally with interested colleagues	Through peer review process for conferences and journals on engineering education
Study site	Instructor's class	Student studies in clinical or natural settings across institutions and contexts
Sampling	The entire class	Representative sample of students chosen according to quantitative (random, controlled) or qualitative (purposeful) research
Human subjects in research (IRB approval)	None or exempt	Yes
Measurement tools/methods	Classroom assessment techniques and surveys; exam questions	Appropriate methods for experimental, quasi-experimental or naturalistic design (surveys, observation, collection of scores on performance measures, interviews, focus groups, analysis of student work products)
Data analysis	Pattern analysis of student opinion and satisfaction; pre-post comparison of student performance	Multiple forms of data analysis (statistical or text) to inform research question
Reporting of results	Anecdotally with colleagues; at regional or national engineering education conference and conference proceedings	Archival education research literature
Impact on engineering education	Informs the individual faculty member and other faculty members; improves learning of future students	Informs the education research community in engineering and other fields
Transferability	Other engineering educators teaching thermodynamics and related topics	Education and engineering communities

In addition, scholarly journals define an expected level of rigor through the process of establishing manuscript requirements. The manuscript requirements for authors submitting to JEE are:

“Research investigations should state the questions addressed and their context relative to the body of knowledge on the subject. The relevant theories should be presented, research design described, limitations acknowledged, and research methods and instruments discussed so as to

permit evaluation of the validity and reliability of the evidence offered. Ethical considerations in data collection, analysis, and reporting involving human subjects should be addressed. A description of any statistical analyses, discussion of the uncertainties, and the significance of the results to advancing engineering education research or practice should be provided” (Journal of Engineering Education, 2010a).

Those requirements are enforced during the review performed by volunteer reviews and editors. The criteria provided by JEE to reviewers of submitted manuscripts requires that all manuscripts:

1. state clearly the questions or propositions addressed and the significance of the research to engineering education research or practice (focus and relevance);
2. situate the research within relevant bodies of knowledge and describe how it contributes to new knowledge (context and contribution);
3. employ research designs, methods, theories, and/or practices appropriate to the research performed (research validity and reliability or credibility and dependability);
4. present original ideas or results of general significance supported by clear reasoning and compelling evidence (results and generalizability or transferability);
5. exhibit clear, concise, and precise exposition that appeals to a broad international readership interested in engineering education research and practice (clarity and readability); and
6. provide tables and figures, as needed, that meaningfully add to the narrative (useful illustrations). (Journal of Engineering Education, 2010b)

In comparison, the call for papers for the CE Division associated with the 2011 ASEE Annual Conference & Exposition simply states: “Papers will be expected to demonstrate an appropriate level of originality and scholarship” (American Society for Engineering Education, 2010b). No further definition of appropriate scholarship is provided.

A potential starting point, in conjunction with the literature previously discussed, is a document entitled *The Craft of Research* that broadly focuses on the performance of all forms of research (educational research included) (Booth, Colomb, & Williams, 2003). This text suggests that technical research must include the following:

1. Pose a research question
2. Review the literature
3. Define methods
4. Execute
5. Evaluate
6. State your claims
7. Provide evidence
8. Situate back in the body of knowledge

These aspects of technical research form the basis for scholarship standards.

Description of Scholarship Standards

A well-formed research question will lead to a “hypothesis or conjecture that can be tested and refuted” (Shavelson & Towne, 2002). As such, a research question should be a logical first step rather than an afterthought. Further, definition of a research question is not only the first step in the process of conducting research, but it can be argued that the research question is perhaps the most important step in the process. A properly formed research question defines the line and direction of research (Booth et al., 2003). All subsequent steps in the process are influenced by the nature of the research question. That is, the literature review, methods, etc. are each informed by the nature of the research question. Because of the importance in defining the subsequent steps in the process of scholarly research, the research question should be clearly and explicitly stated near the start of any resulting publication.

Once a research question has been defined, an investigation must be performed to determine what prior studies have been conducted that in any way relate to the research question. Rigorous research involves an in-depth appreciation for prior research conducted in the area of interest. A researcher can educate oneself through the process of conducting a thorough review of the literature, synthesizing the findings, and considering how those findings influence the proposed study. Linking research to relevant theory requires a broad understanding of the cognate literature. When possible, the proposed study should be defined in terms of previously established theory. The discovery that occurs during a literature review can help avoid “mistakes, wasted resources, and inadequate foundations for future efforts” (Watson, 2009).

The next step in the process of rigorous educational research is planning the method for moving forward with the investigation, while taking into account both the research question and information learned during the literature review. The nature of the methods utilized is very much driven by the research question(s) and must be considered accordingly. Research methods include “the design for collecting data and the measurement and analysis of variables in the design” (Shavelson & Towne, 2002). An often overlooked or rushed part of this step is design of the study. In this step the process for collection and analysis of data is spelled out and provides a road map for each phase of the investigation. Each step should be logically organized and be focused on the research question. Performance of data collection and evaluation of findings must be done in accordance with the study’s design. A failure to adhere to design could significantly impact the validity of the study. Any deviations from the originally defined methods should be acknowledged and reported in resulting dissemination of findings.

Data collection in accordance with the established methods generates results. Results must be presented in an unambiguous manner. Consideration must be given to the use of tables, figures, and photographs that clearly summarize results. Extraneous information, not critical to addressing the research question or understand the study, should not be included when reporting results. The study’s results become the evidence required to support claims. The claims should include a direct response to the research question posed at the start of the study. The strength of the claims is dependent upon the methods used to collect and analyze the data and the nature of the results. Claims are strengthened if the results can be triangulated (Ary, Jacobs, Razavieh, & Sorensen, 2006). Triangulation is the “confirmation of data using multiple data-gathering procedures or multiple sources of data” (Ary et al., 2006).

Conclusions and claims must be considered in relation to the literature and applicable theory investigated in the early stages of the process (Ary et al., 2006). Connections should be made with previously referenced literature to show correlation with or deviation from prior findings. Implications related to the findings should then be discussed. This process situates findings back in the body of previously established knowledge and helps define a study's contribution to advancing that body of knowledge.

The true value of research does not become evident until it is shared with the interested community through publication. It is only through dissemination of findings that we can expect change to occur (Watson, 2009). Dissemination includes, but is not limited to conference presentations, conference papers, journal articles, and books. Regardless of the means of research disclosure, the intent is to invite "scrutiny and critique" by a community of knowledgeable professionals (Shavelson & Towne, 2002). The worth and influence of the research will be judged largely by the quality of the publication. A thorough publication will include at a minimum, a statement of the research question(s), a summary of the applicable literature (this could include identification of a lack of related literature), complete transparency in the methods, clear statement of the findings, consideration of the findings relative to the research question(s), identification of possible limitations, and conclusions that directly connected to the research question and are supported by reported evidence. Sufficient detail must be provided to permit a reader to replicate the study and identify the same results.

Summary

Critical review of prior publications within a field of study is a common practice to evaluate the level of scholarship within that field. Several prior investigations, similar to the current study, were identified. The methods and results presented in the literature have been used to inform the methods of the current study. There are a variety of suggested and widely used standards for educational research and research in general. Through a review of the literature, those standards have been identified and discussed.

Methods

The investigation team consisted of the three authors listed on this manuscript. All three authors are trained in the process of conducting traditional engineering research. The lead author also has an extensive background in the performance of educational research.

Based on the information learned during the literature review process, the authors established a set of educational research criteria that was used to evaluate each of the CE Division conference papers. All three investigators initially met to discuss and define the criteria. The lead author presented examples of published research that exhibited both the preferred criteria and sub-standard research. The second and third authors reviewed a small subset of conference papers and the lead author performed a secondary review. The investigators then discussed the review results and adjusted the criteria as needed.

All conference papers accepted by the CE Division and published in the proceedings for the 2007, 2008, 2009, and 2010 annual conference were thoroughly reviewed. Papers were accessed through the conference proceedings CDs and/or the ASEE conference proceedings website (American Society for Engineering Education, 2007, 2008, 2009, 2010a, 2010c). A review of conference papers associated with the multiple years permits a snap-shot assessment of recent scholarship efforts and also permits an evaluation of recent trends.

The second and third authors of this manuscript roughly divided the total number of conference papers and provided the initial review of each paper. During the initial review, the second and third authors marked the printed copies of the conference papers using a set of codes associated with the research standards criteria. Findings were then recorded in a central electronic data management file. The lead author performed the secondary review of all the marked and coded conference papers. Discrepancies between the primary and secondary review were noted and adjustments were made to the data management file. Throughout the review process, all three investigators met routinely to discuss findings and to ensure that the research standards criteria were consistently applied.

The CE Division generates an annual call for papers with suggested concepts or topic areas. It is not unusual for that call to include a request for papers that would not require adherence to common research standards. For example, the call for papers associated with the 2010 conference included a specific request for papers focused on a general discussion of how the American Society of Civil Engineer's Body of Knowledge 2 was being implemented at particular universities. While the papers submitted to that specific call could have been associated with standard research criteria, preparation did not necessitate such an effort. Accordingly, those papers, and other papers of this type, were marked as "unique." Unique papers were included in the initial data set, but were not included in analysis and discussion of the findings.

As noted in the literature review, evaluation of scholarship could be interpreted as a subjective process. Therefore, the authors utilized the information *Suggested Scholarship Standards* and *Descriptions of Scholarship Standards* to generate the principles shown in Table 2 and used those to evaluate the CE Division conference papers.

In addition to evaluating the accepted conference papers, the authors also completed a review of the papers associated with CE Division awards for multiple years. The CE Division annually awards the Glen L. Martin Best Paper Award and the Gerald R. Seeley Award. The Division bylaws state that the "Glen L. Martin Best Paper Award is given for the best paper on a topic in civil engineering education" (American Society for Engineering Education, 2010d) and the Gerald R. Seeley Award is presented to a member of the Division with 5 years or less of teaching experience based on "the quality of a paper submitted for presentation at the upcoming ASEE Annual Conference" (American Society for Engineering Education, 2010d). Recipients are selected by a slate of prior and current Division officers. Presumably, papers are selected based on accepted standards of scholarship. Thirteen Glen L. Martin Best Paper Award manuscripts were evaluated for the years 1995-2010 and eight Gerald R. Seeley Award manuscripts were evaluated for the years 2003-2010. (Note: one of the Glen L. Martin Best Paper Award

manuscripts was corrupt when downloaded from the ASEE website and could not be located via other means.)

Table 2. Description of Scholarship Standards Utilized in Evaluation of Conference Papers

Scholarship Standard (as used in this study)	Description of Scholarship Standard
Research Question	A clear and testable statement of the intent the study. Could be explicitly identified as the research question or hypothesis. Could also be implied by description of intent. Credit not provided to papers that only included statements such as “This paper presents...” without a clear question or hypothesis.
Literature Review	Properly cited review of literature related to the topic. No minimum number or type of citations required. Although a complete literature review would go in depth on prior studies and theory, credit for literature review provided for even basic connections with the topic.
Journal Citations	Citations originating from a peer reviewed journal based on review of provided reference information.
Conference Citations	Citations originating from a conference published presentation and/or paper based on review of provided reference information.
Website Citations	Citations originating from a website based on review of provided reference information.
Methods	A minimum discussion of the methods used to plan the study, perform the study, collect evidence, and/or evaluate results.
Assessment	Any form of assessment to include, but not limited to, survey(s), interview(s), grade(s), and course/instructor evaluation(s).
Claims	Commonly, but not always, stated as a conclusion. Claims associated with and unrelated to the original research question (if present) were considered.
Evidence	Any form of reported findings. Credit provided only for evidence in support of claims. Defined as “strong” or “weak” based on the degree of connection with claims and triangulation of data.
Situated Back in Literature	Consideration of literature findings when discussing evidence and claims. Identification of contributions to the knowledge base.

After all conference papers received a primary and secondary review, using the scholarship standards identified in Table 2, the data was assimilated and descriptive statistical analysis was performed. The full set of award winning papers was not included in the statistical analysis, with the exception of those associated with 2007-2010. Results of the analysis were collected into a single table and graphs were generated to assist with evaluation of the findings.

While identifying information, such as paper title and author name(s) were included in the data management file for ease of data collection, such identifying information was not pertinent to this study’s research question. Further, it is not the intent of this study to highlight any of the CE Division conference papers as either exemplary or lacking. Accordingly, only aggregate data is provided herein and specific conference papers are not identified in reporting the results of this study.

Results

The results of the data collection and analysis are reported in the Table 3. Annual and total values for each item are reported in the summary table. In total, 265 complete manuscripts were reviewed, evaluated, and re-reviewed. Of those papers, 14 were award papers not associated

with the primary chronological limits of the study (2007-2010) and 5 of those papers were classified as “unique.” After the unique papers and award papers beyond the chronological limits of the study were removed from the data set, 217 papers remained in the primary data set. Values reported in Table 3 were determined using only the non-unique papers.

Table 3. Summary of Results

	2007	2008	2009	2010	Total
DATA SET					
Total Number of Papers	73	56	69	53	251
Unique Papers	11	4	8	11	34
Papers Included in Analysis	62	52	61	42	217
RESEARCH QUESTION					
Percentage of Papers with Research Question	19.4%	13.5%	27.9%	26.2%	21.7%
LITERATURE REVIEW					
Percentage of Papers with Literature Review	80.6%	82.7%	60.7%	85.7%	76.5%
CITATIONS					
Maximum Number of Citations	56	31	58	45	58
Minimum Number of Citations	0	0	0	1	0
Number of Papers with No Citations	1	3	1	0	5
Average Number of Citations	10.2	10.2	11.4	11.7	10.8
Percentage of Total Citations from Journals	24.0%	21.4%	24.1%	23.8%	23.4%
Percentage of Total Citations from Conferences	17.4%	20.6%	20.1%	28.0%	21.2%
Percentage of Total Citations from Websites	21.5%	22.9%	20.3%	15.4%	20.2%
DISCUSSION OF METHODS					
Percentage of Papers with Discussion of Methods	96.8%	71.2%	93.4%	76.2%	85.7%
ASSESSMENT					
Percentage of Papers with Assessment Reported	74.2%	57.7%	78.7%	76.2%	71.9%
Percentage of Papers with Survey(s) as Assessment	27.4%	36.5%	27.9%	52.4%	34.6%
Percentage of Papers with Interview(s) as Assessment	1.6%	1.9%	11.5%	7.1%	5.5%
Percentage of Papers with Grades as Assessment	17.7%	17.3%	27.9%	26.2%	22.1%
Percentage of Papers with Course/Instructor Evaluation(s) as Assessment	17.7%	17.3%	18.0%	19.0%	18.0%
Percentage of Papers with Multiple Forms of Assessment	11.3%	23.1%	21.3%	35.7%	21.7%
CLEAR CLAIMS					
Percentage of Papers with Clear Claims	91.9%	82.7%	93.4%	78.6%	87.6%
Percentage Papers with Clear Claims but No Research Question	72.6%	69.2%	65.6%	52.4%	65.9%
Percentage Papers with Clear Claims but No Evidence in Support of Claims	25.8%	25.0%	23.0%	4.8%	20.7%
EVIDENCE					
Percentage Papers with Strong Evidence	6.5%	25.0%	13.1%	21.4%	15.7%
Percentage Papers with Weak Evidence	64.5%	32.7%	57.4%	54.8%	53.0%
SITUATE BACK IN LITERATURE					
Percentage Papers that Situate Back in Literature	12.9%	5.8%	21.3%	11.9%	13.4%
"WE JUST DID THIS"					
Number of "We Just Did This" Papers	55	40	44	31	170

The total number of citations reports includes all referenced material in the original documents (books, journals, conference papers, websites, personal conversations, reports, etc.). Thus, the summed percentage of journals, conference papers, and websites will not total 100%.

Trends over the four year period for which the CE Division conference papers were reviewed can be readily observed by close inspection of Table 3. Table 4 presents analysis results for the 16 award winning conference papers.

Table 4. 16 CE Division Award Winning Papers (not classified as unique)

% of Award Papers with Research Question	25%
% of Award Papers with Literature Review	81%
% of Award Papers with Discussion of Methods	56%
% of Award Papers with Multiple Forms of Assessment	19%
% of Award Papers with Clear Claims	94%
% of Award Papers with Evidence	69%
% of Award Papers with Findings Situated Back in Literature	19%

Discussion

The total number of papers, on a year-by-year basis, did not fluctuate extensively. It is reasonably assumed that the number of papers accepted to the annual conference is a function of the number of abstracts initially submitted, which is a function of the conference location. Convenience, as well as interest in the conference location, will influence the number of individuals attracted to attending. The number of “unique” papers accepted is influenced by CE Division’s call for papers.

From Table 3 the percentage of papers with a formal research question is low (21.7% over four years). Accepting that a study’s research question is expected to define the subsequent literature review and methods, it is disappointing to realize that less than ¼ of the papers accepted by the Division lack this significant standard of scholarship. The award winning papers (see Table 4) were only slightly better on this metric (25%). However, when compared to Borrego’s findings that 74% of the 700 research abstracts she evaluated were reporting of “author experiences” that lacked a research question (2007), the Division record appears reasonable. However, Borrego also noted that the percentage of “author experience” abstracts continually declined over the 15 year period of her study, while the CE Division papers have shown little measurable decline in the number of papers without research questions.

The percentage of papers that contained a literature review averaged 76.5% over four years and was consistently fairly high. Again, the award winning papers had a slightly higher percentage of papers with a literature review 81% (see Table 4). Using the relatively loose scholarship standard defined for a literature review in this study, it is not surprising that the observed percentage was high. Credit was given for citation of any literature, related to engineering education or otherwise. However, while specific data was not collected on the depth of the literature review, all three authors noted that the majority of the evaluated papers included a very

limited review of prior literature and very few made connections with prior research related to their line of investigation.

A surprising number of papers (5) have been accepted by the Division over the four years that included absolutely no citations. The average number of citations was 10.8 and remained fairly steady throughout the study. This is considerably lower than the average of 15.2 citations that Wankat (1999) reported for JEE articles between 1993 and 1997. While it could be argued that scholarship represented in a conference paper is expected to be less than that of a journal, it should be noted that level of scholarship in JEE in the mid-1990s was significantly less than it is today. Thus, perhaps it is not too unfair to compare the current level of scholarship in the CE Division to past JEE standards. It should also be acknowledged that highly effective and revolutionary publications can and have been generated with a very small number of citations. Thus, it would be inappropriate to judge scholarship strictly in terms the number of citations.

One method for evaluating a literature review, and in-turn a manuscript, is to perform an analysis of the citations. Borrego (2007) suggest that a standard means of citation analysis is to measure research impact by determining the frequency of additional citation. That is, the cumulative frequency of citation of individual references in a manuscript becomes an indication of scholarship. Unfortunately, citation index databases such as Google™ Scholar and Social Science Citation Index® do not consistently list conference papers. Therefore, due to the large number of conference citations referenced in evaluated papers, this method of citation analysis was not performed.

As an alternative to citation frequency, a direct evaluation of the source of citations was conducted for this study. Slightly less than 25% of references reviewed in this study originated from journals, 21.2% were from conference papers, and 20.2% were from website.

Markedly, over 85% of the conference papers evaluated included a discussion of the research methods. Further, 71.9 % of the conference papers reported any form of assessment as part of those methods. Wankat (1999; 2004) reported an increase of JEE articles having some form of assessment from 44% (1993-1997) to 60.2% (1998-2003). From Table 3, there appears to be no significant trend in the percentage of CE Division papers with some form of assessment. Among those CE Division papers with some form of assessment, surveys were used most often (34.6%), followed by grades (22.1%), course/instructor evaluation(s) (18.0%), and interview(s) (5.5%) Table 3 illustrates that historically surveys have been the most popular form of assessment. As Ary et al. (2006) indicate claims are strengthened through the application of triangulated findings. Within the group of papers that included assessment, 30.1% triangulated their findings through the application of multiple forms of assessment, but that only represents 21.7% of the total number of papers reviewed. It is also encouraging to note that the percentage of papers that triangulate their findings through multiple forms of assessment appears to be on the rise.

The use of claims has been historically high (see Table 3) and is also high amongst the award winning papers (94%) (see Table 4). While it is inappropriate to state claims without previously stating a research question, 65.9% of the papers reviewed fall into this category. Without a research question, it is difficult to determine if the study's author(s) found what they were

looking for. Encouragingly, the percentage of papers with claims, but no research question, is on a downward trend. Further, the percentage of papers with claims, but no supporting evidence is also on a downward trend. Over the four year period, the percentage of both “strong” and “weak” evidence in support of claims does not appear to be trending up or down. The strength of reported evidence establishes the power and extent of related claims. Evidence is not strictly collected in the form of assessment and was thus identified separately.

The presence of a research question, literature review, clearly defined methods, some form of assessment, and claims with supporting evidence does fall short of its full potential for the community of interest if the findings are not situated back in the literature. That is, it is important to clarify how a study’s findings build on and advance the existing knowledge in the field of interest. Only 13.4% of the reviewed papers make this crucial final step in evaluating the significance of their findings; while only 19% of the award winning papers makes this same step.

The CE Division papers were not evaluated using Borrego et al.’s (2008) description of “informal” and “formal” engineering education research. However, a similar criterion was applied to the Division papers. Specifically, papers describing an experience (with or without a research question) resulting from a process or approach to education were classified as “we just did this” papers; whereas, a paper presenting the results of a clearly defined study would not be classified in this category. In general “we just did this” papers were interpreted as written as an afterthought to the experience, but more formal research papers were a predetermined part of the research process. The majority of the “we just did this” papers would fall into Borrego et al.’s description of “informal” research. Over 75% of the papers reviewed fall into the “we just did this” category.

While the majority of the 217 papers reviewed for the current study lacked the requirements to be considered representative of rigorous educational research, that does not mean that they lacked interesting and/or useful information. Yet, a broader and more definitive impact would have resulted if established research standards were followed in the performance and reporting of a study.

It should be noted that the authors are not implying criticism of the CE Division, individual papers, or types of papers (including the “we just did this” type). A sub-analysis of the dataset filtered to report results only associated with papers from the U.S. Military Academy, published in the CE Division shows little difference from the dataset as a whole.

This study has been limited to four years of papers accepted by the CE Division of ASEE. The findings may not be generalized beyond that set of data. In addition, the authors applied a self-defined taxonomy to assess the scholarship contained with individual papers. Others might evaluate the Division’s level of scholarship through alternative means.

Conclusions

Self-assessment of scholarship levels through critical review of publications is a common and accepted occurrence among academic communities of practice. An assortment of standards exist for a variety of forms of research, including educational research. Further, little variation exists

between the research standards for discipline specific research and engineering education research. The vast majority of the papers accepted by the CE Division for the annual conference of ASEE (2007-2010) fail to meet one or more aspect of accepted research standards.

The annual ASEE conference is an appropriate outlet for conference papers with a variety of represented rigor. Conference papers that fail to embody full research standards may still contain valuable insight. On the other hand, to truly advance civil engineering education requires research adhering to established standards. The CE Division's recent call for increased rigor with their conference papers is appropriate, but will require definition and implementation of standards. The authors recommend that the Division consider creation of written scholarship standards similar to those used for journal publication. Those standards can be prepared in a manner that still welcomes a variety papers, as long as they meet a minimum level of expected scholarship. What constitutes "a minimum level of expected scholarship" will need to be collectively defined by the Division. Such a set of standards should then be disseminated during the call for papers and subsequently utilized by individuals volunteering to serve as peer reviewers. Significant improvement in civil engineering education will occur if the Division holds itself to measured and progressively higher standards.

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