# Pedagogical Methods for Improving Women's Participation and Success in Engineering Education: A Review of Recent Literature

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By

Lynette Osborne, Ph.D.
Consulting Research Associate
The Institute for Women's Policy Research

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## Introduction

Targeted pedagogical interventions have the potential to help improve women's representation in the engineering disciplines. This Literature Review surveys recent literature that describes and assesses interventions designed to improve women's retention and success in undergraduate engineering education, and that have relevance to efforts to improve gender representation. It focuses on two main bodies of empirical work: 1) research articles that address instructional practices asserted to enhance the attraction, retention, and progression of women in engineering classes, and 2) empirical articles that assess a learning intervention in undergraduate engineering classes that could be related to how college women learn. For each of the following sources of empirical articles, three years were searched (2005 – 2008):

- Society of Women Engineers (SWE) Literature Reviews
- Journal of Engineering Education
- Journal of Women and Minorities in Science and Engineering
- Engineering Education

For the SWE Literature Review, all articles relating to the education of women in undergraduate engineering were identified and reviewed for pertinence in this review. For articles in the three specific journals identified above, each volume was reviewed either online or at a university library. Articles fitting the parameters of this project were then selected and assessed for inclusion in the Literature Review. A total of 281 journal articles were evaluated. See Table 1 for the number of articles reviewed per journal. Thirteen articles that were either a) concerned with instructional practices asserted to enhance the attraction, retention, and progression of undergraduate women in engineering classes, or b) assessed a learning intervention in undergraduate engineering classes that could be related to how college women learn, were identified and included. These articles are reviewed below. In addition to the

Table 1. Journal articles evaluated and selected for inclusion in Literature Review, by journal and year.

| **Journal Title** | **2005 Articles** | **2006 Articles** | **2007 Articles** | **2008* Articles** | **Total Articles by Journal** | **Articles Meeting Criteria** |
|---|---|---|---|---|---|---|
| SWE Literature Review# | 0 | 15 | 7 | 0 | 22 | 3 |
| Journal of Engineering Education | 48 | 39 | 37 | 38 | 162 | 7 |
| Journal of Women and Minorities in Science and Engineering | 22 | 20 | 20 | 5 | 67 | 2 |
| Engineering Education+ | 0 | 8 | 15 | 7 | 30 | 1 |
| **Total articles reviewed** | **70** | **82** | **79** | **50** | **281** | **13=** |

*2008 articles reviewed were from January to June only.
#2008 issue is due after this review was completed
+Publication did not begin until 2006

Literature Review, each article was coded according to a rubric developed by the Center for the Advancement of Engineering Education/ National Academy of Engineering for later uploading to the PR2OVE-IT database. Coding sheets for each article are provided in Appendix A.

## In-Class Pedagogical Interventions

The classroom environment is a particularly powerful determinant of persistence in engineering, especially for women students. Research suggests that student learning and interest in engineering are enhanced when instructors tailor class activities to match students' existing knowledge and their pace of learning, and when instructors actively engage students in learning rather than simply relying on lecturing. Each of the research projects discussed here contributes to the literature related to women's success in engineering because they utilize approaches that previous research suggests are beneficial to the retention and success of students, particularly women students, in engineering (for examples see: Catalano & Catalano 1999; Felder 2005; Nair & Majitech 1995; Riley 2003; Rosser 1999, 1989; Smith, Sheppard, Johnson, & Johnson 1995) . However, none of the articles directly address gender as an issue. Possible implications of these studies for women's engagement in engineering education are discussed in the section titled *Relevance of Gender-Neutral Research for Women's Education* below.

In an effort to increase student learning in an electrical circuit course, Reisslein, Sullivan, and Reisslein (2007) studied the effect of transitioning from worked problems to problem sets. The authors contend that student learning would be positively affected by using different paces of transitioning from worked problems for students to study to having students work through the entire problems.

Reisslein, et al. studied the effects of a computerized, varied-paced problem set program on 235 engineering freshmen enrolled in an electrical circuit course. Of the participants, 186 were male, and 49 were female. Based on a pre-test, the researchers divided students into groups defined by those with high, medium, or low prior knowledge in electrical engineering. Students were then randomly assigned to a treatment group of immediate transitioning (problems assigned with an overview of the information needed, but without a worked example), fast fading (four worked problems were provided but with less information provided for each problem, then additional problems were assigned to be solved), and slow fading (complete worked problems were provided for the first two problems; problems three and four had the first two steps solved and required students to complete the third solution step; in the fifth and sixth problems, students were provided with only the first step and were required to complete the second and third steps; in the last two problems, students worked all three steps independently).

The authors compared pre- and post-test data to evaluate the impact of the fading systems on student learning. According to the authors, using a tailored approach to teaching students about electrical circuit analysis provides a learning environment that allows students with differing levels of prior knowledge to learn and use skills at a pace that encourages each student's learning rather than frustrating and discouraging them. The researchers found that slow transitioning for students with little prior knowledge and fast or immediate paced transitioning for students with some prior knowledge improved learning significantly. The authors conclude that differential pacing for problem sets is associated with increased learning. They also note that incorporating this type of learning approach can be accomplished through a variety of means (e.g.: worksheets, workbooks, blackboard) aside from the computer-assisted problem sets used in their study, which may make it more feasible for instructors who have limited financial resources.

Roselli and Brophy (2006) report on a study geared toward assessing the effectiveness of challenge-based instruction (CBI) as compared to lecture-based instruction in biomechanics courses. Building on the Problem-Based Learning model, CBI has three key characteristics: provides students with challenges that set the stage for increased knowledge and that increase their ability to use the knowledge in applied situations; it is continually encourages students to test their knowledge in different ways; and it gives students opportunities to "refine what they know and reapply this knowledge to a variety of contexts" (p. 312). Students are provided with challenges throughout an academic term that are based on real-life problems. Students are given the opportunity to build on known concepts while learning and applying new ones to solve the challenges.

Assuming that students in a CBI course would have more in-class time to devote to asking questions and gaining clarification of difficult concepts since the instructional approach emphasizes more discussion than the lecture-based sections, the researchers hypothesized that students in the CBI class would outperform those in lecture-based courses. Student grades for two introductory biomechanics courses were evaluated (courses were taught by different instructors, one using a more traditional lecture-based format, and the other using the CBI approach). The researchers triangulated classroom observations, survey data of student perceptions of "how well the course was informed by the HPL framework and their reactions to various methods used during the semester" (p. 315), and final exam questions.

From the triangulated data, the researchers report that students in CBI courses perform as well or better than students in lecture-based courses. In fact, they reported that students who participated in the CBI scored better on some of the more difficult knowledge-based questions from their final exams than those students in lecture classes. Roselli and Brophy conclude that overall, the students exposed to CBI benefited from the pedagogical approach that required active engagement with the course material. They argued that this active engagement allowed students to develop a deeper understanding of the topics, including particularly difficult concepts such as moments. While the authors acknowledge that the CBI method requires more and different planning on the part of instructors, and may be more demanding for students, the positive outcome of increased learning should better prepare students for the workplace and for life-long learning.

In an attempt to provide an innovative approach to students' hands-on lab experience, Read, Hanson, and Levesley (2008), developed, implemented, and assessed an off-site "weblab" experience for engineering students. Acknowledging the difficulty in recruiting and retaining a diverse student base in engineering, the authors developed weblabs: short interactive experiments that can be carried out by the students at any time from anywhere" (p. 52). These weblabs were created for and used by mechanical engineering sophomore undergraduates in their course on vibration and control, and for juniors studying applied mechanics and automatic control. Weblabs allowed students to participate in web-based experiments via their school's intranet, providing them with flexibility in terms of where and when they completed the labs. Additionally, students received immediate feedback on the lab exercises and were then able to repeat labs if necessary.

The researchers used triangulation of several data-gathering techniques to assess the effects of the weblabs on student learning and satisfaction. First, each student was assigned a unique access code that allowed researchers to track how often students logged on to the program. This allowed the authors to track how much time students spent online working on labs. Second, they held discussion [focus] groups with students to acquire feedback on student perceptions of the lab delivery system. Two groups were assessed in terms of their time spent on the weblabs and their post-test scores in the courses. In addition to course instruction, the "local" group attended traditional, hands-on labs as well as using the weblab system, whereas the "distance" group used only the weblabs.

Results of the access data indicated that students returned to the experiments much more often than they needed simply to complete the experiments. The authors surmised that students were using the system to "play" with the experiments after they had completed their assigned tasks. While increased activity may be related to novelty, the discussion [focus] groups with students revealed that students were "checking and repeating results obtained in the hands-on situation, with some using the weblab to experiment further with differing parameters…" (p. 58).

Student overall scores in the course were also used to assess impact of the weblab system. Students who used only the weblab system scored as well in the courses as those who used the weblab in addition to the hands-on lab activities. The authors concluded that, overall, there was a great deal of support for the weblab system in terms of providing a unique delivery system for engineering labs. They argued that this system allows students more time and less pressure to complete engineering experiments allowing students an opportunity to develop their skills. As an alternative delivery system, they argued that it provides a positive experience in engineering lab work that will likely serve to encourage diverse populations to remain in engineering.

In addition to applied engineering proficiency, many engineering students are also expected to learn research skills. Thompson Alford, Liao, Johnson, and Matthews (2005) approached innovation in engineering education by integrating a research component into the undergraduate curriculum. The Research Communications Studio (RCS) is a teaching approach used to draw from communications and engineering in order to help students develop strong written, oral, and graphical communication skills while they advance their engineering research abilities. Engineering students meet weekly in small groups with a communications faculty member, a communications graduate student, and an engineering graduate student. Engineering faculty members served as advisors for the courses as well. Drawing on the Boyer Commission's contention that "no idea is fully formed until it can be communicated, and … the organization required for writing and speaking is part of the thought process that enables one to understand material fully" (p. 3) the RCS uses the weekly meetings as an opportunity for structured discussion of research problems and peer (as well as faculty) discussion of strategies to address the problems.

The researchers gathered information regarding student learning from faculty advisors, graduate mentors, and undergraduate participants to assess the utility of the program. Of specific interest to the project were perceptions of faculty and graduate student mentors' perceptions of undergraduate learning, as well as the type of learning (research and/or communication) that occurred, among the undergraduates. Data collected from the Faculty Survey and Mentor Survey showed that faculty and graduate student mentors believed the participating undergraduates gained a great deal of working knowledge about the research process in engineering as well as how to effectively convey the research in written reports and oral presentations. The participants (students, faculty, and graduate mentors) rated the experience highly in terms of satisfaction. The authors argue that the novel RCS approach for integrating research into engineering using a small group environment provided students with a successful means through which to acquire engineering research skills. They also note that while the participants (students, faculty, and graduate student mentors) rated the experience highly in terms of satisfaction, faculty members also indicated that the undergraduates "were able to think scientifically, understand scientific research, synthesize information from diverse sources, and take more initiative in framing and solving research problems" (p. 305) as a result of participating in the RCS. Overall, the authors contend that the program is an effective way to teach undergraduates about research in a novel, engaging manner.

*In-class innovations are only one way to approach understanding and increasing student achievement in engineering. In the following section, two articles related to faculty impact on student success are reviewed. Specifically, they assess the effects of a faculty development program on student success and retention and the impact of faculty distance to student self-efficacy and self-confidence.*

## Faculty Impact

In an effort to better understand the relationship between student retention and achievement and faculty attitudes, McShannon, Hynes, Nirmalakhandan, Venkataramana, Ricketts, Ulery, and Steiner (2006) studied the faculty development program Gaining Retention and Achievement for Students Program (GRASP). This brief report highlights the faculty development component of the GRASP program that focused on undergraduate's retention and achievement. As faculty members are critical to student retention, this part of the program emphasized modifying teaching techniques, moving from primarily lecture to approaches that integrate activities that are associated with student retention and achievement.

Fifty-three STEM faculty members participated in the GRASP program between spring 1999 and spring 2004. The authors assessed student achievement by comparing "students enrolled in the courses faculty were teaching during GRASP, to students enrolled in the same course taught by the same faculty before they had participated in GRASP" (p. 206). In all, grades from 1,658 pre-GRASP course students were compared to those of 1,854 students enrolled in GRASP courses. The researchers report an average difference of 5.6 percent between the pre-GRASP student grades and the post-GRASP grades in freshmen courses. In sophomore level courses the average increase in grades was 6.7 percent. For junior and senior level courses, the analysis did not yield a significant increase or decrease between pre- and post-GRASP course grades.

In terms of retention, McShannon, et al. assessed whether students remained in the major one year after the faculty member attended the GRASP program. According to the research team, 997 students were registered during 1999-2003 for GRASP courses and 1,032 were registered in non-GRASP courses. The authors reported an average increase in student retention for students who enrolled in GRASP courses of 7.8 percent for freshmen and12.9 percent for sophomores, with no significant difference in retention rates for junior and seniors. The authors maintain that the GRASP faculty development program is positively associated with both student achievement and student retention.

Not only are innovative classroom strategies and participation in faculty development programs related to student performance and retention, but faculty attitudes are as well. In a study of environmental effects, Vogt (2008) assessed the impact of academic integration or faculty distance on student self efficacy, academic confidence, self-regulated learning behaviors, and GPA. Vogt studied engineering students from four universities who belonged to either the Institute of Electronic and Electrical Engineers (IEEE) or the Society of Women Engineers (SWE). In total, 713 students participated in the survey (409 men and 304 women). The study revealed that environmental factors play a statistically significant role in student self-assessments, learning behaviors, and academic performance. For example, Vogt reported that students who felt their instructors showed interest in students, were effective teachers, shared with students, provided opportunities to students, advised them, supported them, and were approachable and accessible (academic integration) scored higher on self-efficacy. Vogt also reported that faculty distance had a negative impact on both students' self-confidence and their self-efficacy. The researcher underscores the role of faculty members in student confidence and self-efficacy, highlighting the need for professors to be available to students as a means of supporting their academic confidence and personal belief in their abilities to succeed.

Overall, this study provides support for the notion that faculty accessibility and support of students is critically important to student confidence in their academic abilities. The environment, as fostered by faculty members, is an important factor in mentoring and nurturing students to be successful in their academic endeavors.

### *Relevance of Gender-Neutral Research for Women's Education*

Despite the absence of analysis by gender, these studies hold important implications for women students. Some inferences can be made about the impact of these interventions for women given the existing pedagogical literature on women in engineering and learning. Specifically, existing literature points to an increase in women's satisfaction with and persistence in engineering when active teaching approaches are utilized. Each of the projects reviewed in this section employed a novel, active teaching/learning approaches to engineering education geared toward student involvement to gain deep learning. Though gender was not directly addressed, it stands to reason that the findings regarding increased learning, program satisfaction, self-confidence, self efficacy, and persistence in the major based on active learning pedagogical approaches, support programs, and instructor attitude may be generalized to women in particular as they mirror existing literature on women's learning and persistence in engineering.

## Effects of External Resources and Support on Retention of Women in Engineering

A number of diverse approaches to providing external support are used to improve the retention rates of female STEM undergraduates. For example, some involve combining living with learning, requiring students not only to take classes together, but also live in the same on-campus residence halls. Others encourage summer research programs aimed at not only completing independent research but also pursuing advanced degrees or careers in STEM fields. Some programs focus on peer mentoring to improve retention or promote membership in professional organizations to provide out-of-classroom supports for female undergraduates. Recent articles on external support programs designed to improve women's retention in STEM fields are reviewed in the following section.

Kahveci, Southerland, and Gilmer (2006), examined the impact of The Program for Women in Science, Engineering, and Mathematics (PWISEM) that sought to improve female retention rates through a living-learning community. Students were required to reside together, were provided with study partners, and participated in a one-credit course: "Women in Science Colloquium." Participants were allowed to reside elsewhere after the first year. The program was based on the assumption, founded in the literature, that when women students participate in a variety of activities aimed at fostering both student-student and faculty-student interactions, they are more likely to remain in the STEM field.

Kahveci et al. compared female undergraduates in the PWISEM program with female and male undergraduates in Honors General Chemistry who were not in the PSWISEM program over the course of an academic year to see if there were any differences between the groups in terms of interest, confidence, and determination to pursue a science, mathematics, or engineering degree. Thirty-five PWISEM participants as well as 63 Honors General Chemistry students (34 men, and 29 women) participated in the survey that was administered as a pre- and post-test at the beginning and end of the semester.

The authors report that women who participated in the support programs for women in the science, mathematics, and engineering fields had higher retention and success rates than both women and men who did not participate in support programs. Kahveci, et al. report that the positive outcomes experienced by the treatment group were the result of the PWISEM program. They report that the close student-faculty relationships fostered as a part of the program, the opportunities for research, mentoring, and overall academic networking are associated with retention. The authors note that efforts to retain women in engineering should take a holistic approach from the first year of college, through programs such as the PWISEM living-learning community program, which combines a supporting living environment and academics.

Grimberg, Langen Compeau, and Powers (2008), evaluated the Clarkson University Research Experience for Undergraduates (REU) Summer Site Program in Environmental Science and Engineering to assess its impact on participants' likelihood of pursuing advanced degrees and careers in science or engineering. The 10-week summer program involved conducting and presenting individual research projects, attending thematic lectures and seminars, participating in community building activities and field trips, and workshops on further opportunities for research, graduate school, and careers. This article analyzes the pre-and post-participation surveys given to students in the program over the course of seven years. During the fourth year of the program, a weekly seminar on environmental sustainability was added to the program as a way of improving the students' awareness and appreciation of the relevance, impact, and importance of their research and the work of other practitioners on the greater world.

This evaluation of the REU program at Clarkson involved administering pre- and post-test surveys to 78 program participants (41 women and 37 men). The survey assessed student intent to attend graduate school and their desire to pursue a research career, among other factors. The survey results were mixed. According to the authors, over 60 percent of former program participants had gone on to graduate and professional school programs, but the intention of these students to pursue careers in research fields had decreased after completing the program. While the program does not target women in particular, the results of the research may speak to the intentions of women, since more than half of the participants were female. Overall, however, Grimberg, et al. suggest that participants in the program are likely to continue with their education beyond their undergraduate careers, but not necessarily in STEM areas of study. They conclude that the program is successful in encouraging its students, including its female students, to pursue graduate degrees in general, not just in engineering.

Micari and Drane (2007), evaluated the effectiveness of the Gateway Science Workshop (GSW) at Northwestern University, which is a peer-led, small-group workshop geared toward increasing learning for minority and women in STEM. The authors evaluated five years of data from students in five different STEM subject areas (biology, physics, chemistry, mathematics, and engineering).

The GSW groups are made up of five to seven students (in roughly 100 groups), led by a peer who has taken the course previously, who meet once a week each semester to work through conceptual problems created by the professors of each course. The evaluation of the GSW program involved interviewing 45 students individually (26 women and 19 men), as well as conducting 34 focus groups of 6 to10 students each across science and mathematics disciplines between 2001 and 2005. The results of the interviews and focus groups indicated positive effects for students who participated in the GSW program in terms of higher grades, better retention of students in course sequences, and higher overall course satisfaction compared with non-program participants. These effects, however, appeared more prominent for minority and female students in the GSW program who experienced even higher grades and higher retention rates in the course sequences than non-minority program participants. According to the authors, this suggests that this peer-led, small-group workshop was able to successfully combat the particular barriers traditionally faced by minority and female students in science and mathematics disciplines in a way that improved their overall college experience. They argue that the informal mentoring and academic guidance offered by peer facilitators is particularly beneficial to women, and that after participating in this program, they feel less isolated and more integrated in their fields of study and universities.

Hartman and Hartman (2005) assessed the impact of professional organization membership on women undergraduate engineering students. The authors compared women university students who participated in discipline-specific, mixed-gender organizations, those who belonged to the student chapter of the Society of Women Engineers (SWE), and those who did not affiliate with student organizations to understand how participation related to professionalism and the development of engineering social capital.

Sixty-two women engineering students participated in the survey that was administered once a semester for one academic year. The researchers report virtually no difference between women undergraduate engineering students who participated in SWE versus a mixed-gender organization in terms of academic achievement, self-confidence, and future commitment to the engineering field. The study did indicate that involvement in professional organizations, regardless of the gender affiliation of that organization, has a positive impact on academic achievement, self-confidence, and future commitment to engineering for women.

Hartman and Hartman argue that their research dispels the myth that female-only professional engineering organizations isolate women further from the engineering field. In fact, they suggest that an overall way to increase female retention in engineering at the undergraduate level is to encourage women to participate in a professional organization, regardless of whether it is intended for women only or both genders, as both have positive impacts on increasing self-confidence and retaining female engineering students.

*Overall, the articles in this section indicate that many types of external support are effective in encouraging women to achieve and remain in engineering. The articles reviewed here suggest that participating in networking, mentoring, and community-building activities is associated with higher grades, better retention rates, and higher satisfaction. However, the specific details of support programs may be critical in encouraging STEM commitment as opposed to more generally increasing educational retention, as shown by the Grimberg, et al. study.*

## Longitudinal Analyses of Factors Related to Retaining Women in Engineering Education

In the past few years, several studies have been published examining large datasets in order to better understand the variables that contribute to differences in the training and retention of engineering students and of women particularly. Three studies in particular have contributed unique and valuable information about the factors that help or hinder women's chances of succeeding in engineering programs.

Hartman and Hartman (2006) conducted a study to assess the effectiveness of the Rowan University engineering program. The RU program, established in 1996, was designed to thoroughly incorporate teamwork and interdisciplinary cooperation into the curriculum, while emphasizing a low student-to-faculty ratio and a strong faculty-student mentoring and advising program. The goal was to change the experience of engineering education to make students, particularly women students (who made up only 71 of the 352 students in the study), more likely to succeed and persist in the program.

The study was conducted to assess how successful the program had been in retaining female students and reducing attrition rates generally. The study is ongoing, with surveys distributed twice a year in required classes, reaching almost all students in the engineering program. Hartman and Hartman report longitudinal data collected between 1996, the initiation of the Rowan program, and 2002. Importantly, data were collected from students who left the engineering program before obtaining a degree, allowing for comparisons of 'stayers' (n = 319) and 'leavers' (n = 33).

Initial analyses of the data revealed that not only is Rowan's overall retention rate higher than the national average, but that no significant difference is observed between the retention rate for women (85 percent) and that for men (80 percent). The authors consider these statistics a signal of the success of the program, but go on to examine the factors contributing to the attrition that did occur in the program. Students who left the engineering program had lower grades in high school math and science classes, but also had higher SAT verbal scores, suggesting that attrition may be partially due to a 'pulling' effect from other majors or career paths. In addition, leavers did not, on average, have less confidence in their engineering abilities, but rather less confidence in how well suited they personally were for a career in engineering, indicating again that the choice to leave may often be more about the fit of a career in engineering than about an inability to cope with the rigors of the training program.

A large set of analyses by gender revealed several key differences in the attrition patterns of men and women students. Broadly summarized, men students who left the engineering program were generally less well-prepared for the program and had lower grades in their college classes than did stayers. The academic performance of female leavers, however, did not differ from students who remained in the program. Female leavers were more likely than stayers to report concerns about career/family conflicts, as well as reservations about the level of freedom or independence they could expect in an engineering career. The attrition rate was lower among women who participated in the Society of Women Engineers (SWE) on campus or who had engineering internships or jobs while in school, and those with exposure to these experiences also expressed less concern about career-family conflict in the field. The authors suggest that explicitly addressing work/life balance issues with women students can contribute to reducing attrition among female students.

Zhao, Carini, and Kuh (2005), used data from the 2001 and 2002 administrations of the National Survey of Student Engagement (NSSE) to assess the satisfaction and involvement of students in science, mathematics, engineering, and technology (SMET) majors. The sample size was 106,460, allowing for comparison of responses by gender and by major (both within SMET majors and between SMET and non-SMET majors).

The NSSE contains questions regarding students' level of engagement on campus (a category broken down into numerous subcategories of engagement experience), self-reported gains of several kinds, perceived level of support in the campus environment, and overall student satisfaction. All student responses were subjective, and no objective information (e.g. GPA or graduation rates) was analyzed in this study.

Though the subjective nature of the data makes it difficult to draw conclusions about the importance of the variables studied in influencing outcomes, the authors note that, "female SMET majors are at least as engaged in effective educational practices as their male counterparts" (p. 54). However, the authors note that women do report lower engagement on some measures. Compared to men, women were less likely to ask questions in class or contribute in class and were less engaged with class presentations, teamwork with other students, or tutoring other students. The authors note that reduced female engagement may support an atmosphere of "social tokenism," whereby women in engineering and other SMET fields may perform well academically but are often excluded from a male-dominated network of gossip and strategies for advancement that advantage men in less well-defined ways. Hartman and Hartman suggest a number of ameliorative strategies for improving situations for women and other underrepresented minorities in STEM majors. They suggest that classrooms and curricula be revised to include a wider array of pedagogical techniques and collaborative learning ventures to accommodate students with a wide array of learning styles. They also promote the idea of providing programs and academic counseling services to help women overcome societal obstacles to success in these fields.

Bernold, Spurlin, and Anson (2007) surveyed North Carolina State University engineering students over a three-year period, beginning with 1,022 first year engineering students (of whom 176 were female and 846 were male). The study focused on how student learning styles influence success in engineering programs. The researchers utilized the Learning

Type Measure (LTM)[1] to categorize students as one (or more) of four learning types: Type 1 (Why?) students favor discussing ideas, opinions, and subjective information; Type 2 (What?) students prefer to critique information and assimilate abstract facts into coherent theories; Type 3 (How?) students like to experiment and excel at tasks that require objective thinking and measurement; and Type 4 (What-If?) students prefer to use trial-and-error problem solving skills. Students who scored equally high on more than one of the types and students who did not take the LTM were dropped from analyses of the LTM data.

Understanding the role of LTM in outcomes for men and women engineering students is complex. Generally speaking, Type 2 (What?) students had the highest GPA in engineering classes; most of the men engineering students who were categorized were categorized as Type 2 (38 percent, with 75 percent of students categorized). More than twice (21 percent) as many women than men (8 percent) were categorized as Type 1 (Why?) students; Type 1 students had the second-lowest engineering GPA, after Type 4 (What-If?) students. While these patterns might indicate that women would generally be at a disadvantage, this is not the case. Across all learning types, female students have higher GPAs (average = 3.24) than men (average = 2.97). However, there is no gender difference in the likelihood that freshmen engineering students matriculated into specific engineering majors (a process requiring a minimum GPA in certain classes), a necessary step before students can graduate with an engineering degree. The lack of a difference in matriculating to an engineering major despite women's higher GPAs may be explained by the fact that women were more likely than men to remain enrolled in a non-engineering major, indicating that though they are more objectively successful, many women choose to leave engineering programs anyway.

The data in this study suggest that, on the whole, the women who enter engineering programs do as well or better than the male students; however, possibly due to learning styles that may be less well-suited to a "chalk-and-talk" style of engineering classroom, they are more likely to switch to a non-engineering major. The authors suggest that a broadening of curriculum and classroom teaching styles and strategies would help retain a greater proportion of students in engineering, especially those students with learning styles putting them at a disadvantage in a typical engineering classroom.

On the whole, these studies suggest that while women engineering students perform as well or better than men students on objective measures of performance, they are still susceptible to the effects of social and cultural biases and expectations. Interventions designed to improve the participation and retention of women in engineering must address these challenges in order to be effective.

## Summary

Understanding how and under what circumstances women flourish in engineering education is of critical importance to developing and implementing programs that draw women into engineering education and eventually into the engineering workforce. Research presented in this Review shows the promise of carefully designed programs to promote women in engineering

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[1] Note that the Learning Type Measure is similar to how to Kolb's (1984) Learning Cycle (Why?=Reflecting, What?=Experiencing, How?=Theorizing, and What-If?=Experimenting) has been characterized.

education as well as the difficulty of accurately targeting the right combination of supports. Overall, research indicates that many factors and types of programs can help to improve the position of women in engineering. For instance, in-class pedagogical innovations where instructors use student-centered teaching/learning approaches tend to be associated with a better learning experience for students, especially women students (see: Catalano & Catalano 1999; Felder 2005; Nair & Majitech 1995; Riley 2003; Rosser 1999, 1989; Smith, Sheppard, Johnson, & Johnson 2005). Faculty attitudes toward students, including their perceived distance from students are also related to women's satisfaction and performance.

In addition to in-class teaching innovations and faculty attitudes, women student success is also affected by the support they receive from broader programs and professional organizations. Longitudinal studies show that some programs and innovations designed to support and nurture women in engineering can be successful over time in providing many women with sufficient support and skills to remain in a STEM field of study.

The articles summarized in this Literature Review provide evidence to support the ongoing development and implementation of additional in-class and programmatic innovations to encourage women's success in engineering.

## References

Bernold, L.E., Spurlin, J.E., and Anson, C.M. 2007. “Understanding Our Students: A Longitudinal-Study of Success and Failure in Engineering With Implications for Increased Retention.” *Journal of Engineering Education* 96(3): 263-274.

Catalano, G.D. and Catalano, K. 1999. “Transformation: From Teacher-Centered to Student-Centered Engineering Education.” *Journal of Engineering Education*, January: 59-64.

Felder, R.M. 1995. “A Longitudinal Study of Engineering Student Performance and Retention: IV. Instructional Methods and Student Responses to Them.” *Journal of Engineering Education, 84*(4): 361-367.

Grimberg, S. J., Langen, T. A., Compeau, L. D., and Powers, S.E. 2008. “A Theme-Based Seminar on Environmental Sustainability Improves Participant Satisfaction in an Undergraduate Summer Research Program.” *Journal of Engineering Education* 97(1): 95-103.

Hartman, H., and Hartman, M. 2006. “Leaving Engineering: Lessons from Rowan University’s College of Engineering.” *Journal of Engineering Education* 95(1): 49-61.

Hartman, H., and Hartman, M. 2005. “Undergraduate Women’s Participation in Professional Organizations.” *Journal of Women and Minorities in Science and Engineering* 11(1): 117-137

Kahveci, A., Southerland, S.A , and Gilmer, P.J. 2006. “Retaining Undergraduate Women in Science, Mathematics, and Engineering.” *Journal of College Science Teaching* 36(3): 34-38.

Kolb**,** D.A. 1984**.** *Experiential Learning**:** Experience as the Source of Learning and Development**.*** Prentice-Hall: Englewood Cliff, CA.

McShannon, J., Hynes, P., Nirmalakhandan, N., Venkataramana,G., Ricketts, C., Ulery, A. and Steiner, R. “Gaining Retention and Achievement for Students Program: A Faculty Development Program.” *Journal of Professional Issues in Engineering Education and Practice* 132(3): 204-208.

Micari, M., and Drane, D.. 2007. “Promoting Success: Possible Factors Behind Achievement of Underrepresented Students in a Peer-Led Small-Group Stem Workshop Program.” *Journal of Women and Minorities in Science and Engineering* 13(3): 295-315.

Nair, I. and Majetich, S. 1995. Physics and engineering in the classroom. In S.V. Rosser (Ed.), *Teaching the majority: Breaking the gender barrier in science, mathematics, and engineering* (pp. 25-42). New York, NY: Teachers College Press.

Read, E., Hanson, B., and Levesley, M. 2008. “Using Weblabs as a Tool to Support a Culturally Diverse Student Cohort.” *Engineering Education* 3(1): 52-61.

Reisslein, J., Sullivan, H., and Reisslin, M. 2007. “Learner Achievement and Attitudes under Different Paces of Transitioning to Independent Problem Solving.” *Journal of Engineering Education* 96(1): 45-55.

Riley, D.  2003.  “Employing Liberative Pedagogies in Engineering Education.”  *Journal of Women and Minorities in Science and Engineering, 9*: 137-158.

Roselli, R.J. and Brophy, S. P. 2006. “Effectiveness of Challenge-Based Instruction in Biomechanics.” *Journal of Engineering Education* 95(4): 311-324.

Rosser, S.V.  1998.  “Group Work in Science, Engineering, and Mathematics.”  *College Teaching, 46*(3): 82-89.

Rosser, S.  1989.  “Creating an Environment that is Conducive to Learning for the Majority.” *Journal of The Freshman Year Experience, 1*(1): 53-63.

Smith, K.A., Sheppard, S.D., Johnson, D.W., and Johnson, R.T. 2005.  Pedagogies of Engagement:  Classroom-Based Practices.  *Journal of Engineering Education, Jan,* 87-101.

Thompson, N.S., Alford, E.M., Liao, C., Johnson, R. J., and Matthews, M. A. 2005. “Integrating Undergraduate Research into Engineering: A Communications Approach to Holistic Education.” *Journal of Engineering Education* 94(3): 297-307.

Vogt, C.M. 2008. “Faculty as a Critical Juncture in Student Retention and Performance in Engineering Programs.” *Journal of Engineering Education* 97(1): 27-36.

Zhao, C., Carini, R.M., and Kuh, G.D. 2005. “Searching for the Peach Blossom Shangri-La: Students Engagement of Men and Women SMET Majors.” *The Review of Higher Education* 28(4): 503-525.

# APPENDIX A: Summary of Coding Sheets

As part of this report, the thirteen articles were coded according to the CASEE/NAE rubric for later uploading to the PR2OVE-IT database. This summary includes the combined basic information from all of the coding sheets and corresponding tables. It is organized following the order of the coding sheet provided by CASEE/NAE, a copy of which is included in this report.

Question 2 addresses the subject and content area in which the intervention took place. There are seven major subcategories; however, the articles in this report only fell under three of these subcategories- *engineering major, engineering fundamentals*, and *other sciences*. Under the subcategory of *engineering major*, seven (53.8%) of the interventions included in this report took place in general or introductory engineering courses. The second most common subject was mechanical engineering representing four of the thirteen (30.8%) of the articles, followed closely by chemical engineering and electrical engineering, each were part of 23.1% of the articles. Other subject areas represented in one or two studies in this subcategory are civil engineering, environmental engineering, computer engineering, computer engineering, and bioengineering and biomedical engineering (See Table 1).

Each of the other two subcategories included one article. For *engineering fundamentals*, the intervention fell in the context of electric circuits, and for *other sciences*, the intervention fell under general science studies (See Table 1).

**Table 1. Content/Subject Area**

| Engineering major | Number of Articles | Percent of all articles |
|---|---|---|
| General/introduction | 7 | 53.8% |
| Mechanical engineering | 4 | 30.8% |
| chemical engineering | 3 | 23.1% |
| Electrical engineering | 3 | 23.1% |
| Civil engineering | 2 | 15.4% |
| Environmental engineering | 1 | 7.7% |
| Computer engineering | 1 | 7.7% |
| Bioengineering and biomedical engineering | 1 | 7.7% |

| Engineering fundamentals | Number of articles | Percent of all articles |
|---|---|---|
| Electric circuits | 1 | 7.7% |

| Other Sciences | Number of articles | Percent of all articles |
|---|---|---|
| Science (general) | 1 | 7.7% |

Question 3a focuses on the demographic information of the sample. Nine of the thirteen articles (69.2%) examined studies that did not target a specific population and were coded as "General Population." Two of the articles (15.4%) targeted a specific group based on gender, and one (7.7%) targeted a specific group based on minority status. The final intervention targeted faculty (See Table 2).

**Table 2. Population**

| Population | Number of articles | Percent of all articles |
|---|---|---|
| General Population | 9 | 69.2% |
| Gender | 2 | 15.4% |
| Female | 1 | 7.7% |
| Underrepresented Minority | 1 | 7.7% |
| Faculty | 1 | 7.7% |

Question 3b looks at the location of the study. Almost all of the studies (92.3%) took place in the United States (See Table 3).

### Table 3. Location

| Location | Number of Articles | Percent of all articles |
|---|---|---|
| United States | 12 | 92.3% |
| Outside the United States | 1 | 7.7% |

Question 4 is about sample size. Six of the studies (46.2%) had more than 100 subjects. Four of the studies (30.8%) had 51-100 subjects, and two (15.4%) of the studies had 26-50 subjects. The number of subjects what not specified for one of the studies (See Table 4).

### Table 4. Sample Size

| Sample size | Number of articles | Percent of all articles |
|---|---|---|
| More than 100 subjects | 6 | 46.2% |
| 51-100 subjects | 4 | 30.8% |
| 26-50 subjects | 2 | 15.4% |
| Not specified | 1 | 7.7% |

Question 5a looks at the type of institution at which the intervention took place. All twelve of the institutions in the United States are four-year institutions. Nine of these studies did not provide any additional information about the institution. However, two studies specified that the intervention took place at a doctoral/research institute, and one of the studies was based at a special engineering school (See Table 5).

## Table 5. Type of Institution

| Type of institution | Number of articles | Percent of all articles |
|---|---|---|
| Four-year | 12 | 92.3% |
| No institutional code | 9 | 69.2% |
| Doctoral/research | 2 | 15.4% |
| Special engineering | 1 | 7.7% |
| Foreign | 1 | 7.7% |

Question 5b provides information about the social arrangement that the subjects were organized in during the intervention. The most common type of arrangement was the small group (38.5%) followed closely by the whole class (30.8%) and individual (23.1%). In addition, one of the studies organized students into teams (See Table 6).

## Table 6. Social Arrangement

| Social arrangement | Number of articles | Percent of all articles |
|---|---|---|
| Small group | 5 | 38.5% |
| Whole class | 4 | 30.8% |
| Individual | 3 | 23.1% |
| Team | 1 | 7.7% |

Question 6 focuses on the primary setting of the intervention. Over half (53.8%) of the interventions were applied at the individual level. In four of the thirteen interventions (30.8%), the interventions were applied at the classroom/course level, while three of the thirteen interventions (23.1%) were applied at each the program level and outside of the classroom. Interventions were each applied at the department level, institution/college/university level, tutorial/workshop setting, and studio in one article. Lastly, one intervention fell in the "other" category, with the intervention applied at the professional group level (See Table 7).

## Table 7. Locus of Application

| Locus of application | Number of articles | Percent of all articles |
|---|---|---|
| Individual | 7 | 53.8% |
| Classroom/course | 4 | 30.8% |
| Program | 3 | 23.1% |
| Outside the classroom | 3 | 23.1% |
| Department | 1 | 7.7% |
| Institution/college/university | 1 | 7.7% |
| Tutorial/workshop | 1 | 7.7% |
| Studio | 1 | 7.7% |
| Other | 1 | 7.7% |

Question 7 is about the targeted level for study. Of the articles in this report, 53.8% targeted freshman, 38.5% targeted sophomores, 38.5% targeted juniors, and 38.5% targeted seniors including one senior-level Capstone course. One of the interventions targeted faculty, and one article did not specify the targeted level (See Table 8).

**Table 8. Level**

| Level | Number of articles | Percent of all articles |
|---|---|---|
| Freshman | 7 | 53.8% |
| Junior | 5 | 38.5% |
| Senior | 5 | 38.5% |
| Capstone | 1 | 7.7% |
| Sophomore | 5 | 38.5% |
| Faculty | 1 | 7.7% |
| Not Specified | 1 | 7.7% |

Question 8 provides information about theories guiding the study. Seven of the thirteen articles (53.8%) did not specify any guiding theory behind the interventions. Three of the thirteen articles (23.1%) explicitly stated that they were guided by Learning Styles Theory, and three articles also stated they were guided by Cognitive/Constructivist Theory. Finally, one article (7.7%) was guided by Bloom's Taxonomy (See Table 9).

**Table 9. Theory**

| Theory | Number of Articles | Percent of all articles |
|---|---|---|
| No theory/not specified | 7 | 53.8% |
| Learning styles | 3 | 23.1% |
| Kolb | 1 | 7.7% |
| Cognitive/constructivist | 3 | 23.1% |
| Bloom's Taxonomy | 1 | 7.7% |

Question 9 looks at the nature of the research, including the research design or methods. Quantitative methods were used in eleven of the thirteen (84.6%) articles. The second most common method used in the interventions examined here was a pre-/post-test or survey that was included in ten of the interventions (76.9%). Comparison groups were used in six studies (46.2%), and qualitative methods were used included in five of the articles (38.5%). Experimental designs were part of three interventions (23.1%), including one with control groups and one with a random sample. There were three longitudinal studies (23.1%) and one anecdotal study (7.7%). Also, one method was included in the "other" category- the study included focus groups and interviews (See Table 10).

### Table 10. Nature of Research

| Nature of research | Number of articles | Percent of all articles |
|---|---|---|
| Quantitative | 11 | 84.6% |
| Pre-/post-test or survey | 10 | 76.9% |
| Comparison groups | 6 | 46.2% |
| Qualitative | 5 | 38.5% |
| Experimental | 3 | 23.1% |
| Experimental with control groups | 1 | 7.7% |
| Random sample | 1 | 7.7% |
| Longitudinal | 3 | 23.1% |
| Anecdotal | 1 | 7.7% |
| Other | 1 | 7.7% |

Question 10a examines the duration of the intervention. There are two categories of duration. The first is an *amount of time*, and the second is a *number of interventions*. Interventions that fell under *amount of time* were more common (69.2%) than those that fell under the *number of interventions* (15.4%) category. Under *amount of time*, three interventions lasted the entire program, three interventions lasted for one term, two interventions lasted one academic year, and one intervention lasted more than one academic year but less than the entire program. Under *number of interventions,* one intervention included short, one-time interventions of less than a term, and one study included multiple interventions over the course of a term. Two of the articles (15.4%) did not specify the duration of the intervention (See Table 11).

### Table 11. Duration of the Intervention

| Duration of the intervention | Number of articles | Percent of all articles |
|---|---|---|
| Amount of time | 9 | 69.2% |
| Entire program | 3 | 23.1% |
| One term | 3 | 23.1% |
| One academic year | 2 | 15.4% |
| More than one academic year but less than the entire program | 1 | 7.7% |

| | | |
|---|---|---|
| Number of interventions | 2 | 15.4% |
| Short, one-time interventions of less than a term | 1 | 7.7% |
| Multiple interventions over the course of a term | 1 | 7.7% |
| Not Specified | 2 | 15.4% |

Question 10b is about the length of the study. Three studies (23.1%) each lasted two academic years or more than three academic years. Two studies (15.4%) each lasted either less than a term, one academic year/two semesters, or three academic years. One study (7.7%) lasted one term (See Table 12).

**Table 12. Length of Study**

| Length of study | Number of articles | Percent of all articles |
|---|---|---|
| Two academic years | 3 | 23.1% |
| More than three academic years | 3 | 23.1% |
| Less than a term | 2 | 15.4% |
| One academic year/two semesters | 2 | 15.4% |
| Three academic years | 2 | 15.4% |
| One term | 1 | 7.7% |

Question 11 addresses the practice in engineering education to which the intervention is related. This question is divided into six categories: *Teaching and Learning, Educational Technology, Communication and Information Technology, Development of Professional Skills, Student Assessment,* and *Student Retention.*

Most of the interventions studied fall under the *Teaching and Learning* subcategory. Faculty/student interaction was the most common intervention (53.8% of all articles).

Next is problem solving with four out of the thirteen articles (30.8%) followed by an active learning and inquiry/discovery/hands-on approaches, each used in three of the articles (23.1%). Several other interventions in this category appeared in one or two of the articles. See Table 13a for the full list of interventions in this subcategory.

## Table 13a. Practice in Engineering Education: Teaching and Learning

| Practice in Engineering Education | Number of articles | Percent of all articles |
|---|---|---|
| Teaching and Learning | | |
| Faculty/student interaction | 7 | 53.8% |
| Problem solving | 4 | 30.8% |
| Active learning | 3 | 23.1% |
| Inquiry/discovery/hands-on | 3 | 23.1% |
| Other: challenge-based; challenge of exams | 2 | 15.4% |
| Teams | 2 | 15.4% |
| Lecture (traditional) | 2 | 15.4% |
| Projects | 2 | 15.4% |
| Lecture (active) | 2 | 15.4% |
| Peer teaching | 2 | 15.4% |
| Supplementary instruction | 2 | 15.4% |
| Presentation | 2 | 15.4% |
| Collaberative/cooperative learning | 1 | 7.7% |
| Laboratory (reformed) | 1 | 7.7% |
| Personalized system of instruction | 1 | 7.7% |
| Learning styles | 1 | 7.7% |
| Journals | 1 | 7.7% |
| Tutorial | 1 | 7.7% |
| Independent research | 1 | 7.7% |
| Integrated curriculum | 1 | 7.7% |
| self-paced instruction | 1 | 7.7% |
| Studio approach | 1 | 7.7% |

The second most common subcategory was *Student Retention*. The most common intervention in this subcategory was mentoring (30.8% of all articles), followed by team work and supplementary/remedial coursework, each of which were presented in three studies (23.1% of all articles). Peer mentoring, site visits, student community, and common course scheduling were each types of interventions included in two articles (15.4%). Several other interventions were included in only one article. See Table 13b for the full list of interventions in this subcategory.

**Table 13b. Practice in Engineering Education: Student Retention**

| Practice in Engineering Education | Number of Articles | Percent of all articles |
|---|---|---|
| Student Retention | | |
| Mentoring | 4 | 30.8% |
| Team work | 3 | 23.1% |
| Supplementary/remedial coursework | 3 | 23.1% |
| Peer mentoring | 2 | 15.4% |
| Site visits | 2 | 15.4% |
| Student community | 2 | 15.4% |
| Common course scheduling | 2 | 15.4% |
| Faculty development | 1 | 7.7% |
| Communal housing | 1 | 7.7% |
| Learning communities | 1 | 7.7% |
| Professional speakers | 1 | 7.7% |
| Skill enhancement | 1 | 7.7% |
| Research internships | 1 | 7.7% |

*Student Assessment* was the third most represented subcategory. Self-assessment, reflective writing, goals, and performance assessment were each represented in one article (7.7%). Time spent relaxing was also an intervention that was included in this subcategory and coded as “other” (See Table 13c).

## Table 13c. Practice in Engineering Education: Student Assessment

| Practice in Engineering Education | Number of Articles | Percent of all articles |
|---|---|---|
| Student Assessment | | |
| Other: time spent relaxing | 1 | 7.7% |
| Self-assessment | 1 | 7.7% |
| Reflective writing | 1 | 7.7% |
| Goals | 1 | 7.7% |
| Performance assessment | 1 | 7.7% |

*Communication and Information Technology* was the fourth most common subcategory. Online course content was an intervention included in two studies (15.4%), and web-based learning and distance learning were each included in one study (7.7%) (See Table 13d).

## Table 13d. Practice in Engineering Education: Communication and Information Technology

| Practice in Engineering Education | Number of Articles | Percent of all articles |
|---|---|---|
| Communication and information technology | | |
| Online course content | 2 | 15.4% |
| Web-based | 1 | 7.7% |
| Distance learning | 1 | 7.7% |

The least two subcategories represented were *Educational Technology* and *Development of Professional Skills.* Under *Educational Technology,* interactive technology was found in one articles (7.7%) as was a tutorial program. The only intervention that falls under the *Development of Professional Skills* subcategory is participation in professional organizations and was coded as "other" (See Table 13e).

### Table 13e. Practice in Engineering Education: Educational Technology and Development of Professional Skills

| Practice in Engineering Education | Number of articles | Percent of all articles |
|---|---|---|
| Educational Technology | | |
| Interactive | 2 | 15.4% |
| Tutorial | 1 | 7.7% |
| Development of Professional Skills | | |
| Other: participation in professional organizations | 1 | 7.7% |

Question 12 addresses the methods used to evaluate the interventions. The methods represented in the articles included fall into two subcategories: *Teaching and Learning* and *Student Retention.* The vast majority of methods fell under the *Teaching and Learning* subcategory, with academic performance and surveys/questionnaires being the most common methods in this group with each being used in eight of the thirteen studies (61.5%). Academic performance was assessed most often by GPA (30.8% of all articles), followed by grades (15.4% of all articles), achievement tests (7.7% of all articles), and exams (7.7% of all articles). Student comments/feedback/reflections were the next most common methods and were used in six of the thirteen studies (46.2%). Five of the thirteen (38.5%) studies used pre-/post-test or survey difference to evaluate the interventions. Both performance assessment and self-assessment were used in three studies (23.1%). Several other methods were used only once to evaluate an intervention. See Table 14a for the full list of methods of evaluation.

### Table 14a. Method of Evaluation: Teaching and Learning

| Method of Evaluation | Number of articles | Percent of all articles |
|---|---|---|

| | | |
|---|---|---|
| Teaching and Learning | | |
| Academic Performance | 8 | 61.5% |
| GPA | 4 | 30.8% |
| Grades | 2 | 15.4% |
| Achievement test | 1 | 7.7% |
| Exams | 1 | 7.7% |
| Surveys/questionnaires | 8 | 61.5% |
| Student comments/feedback/reflections | 6 | 46.2% |
| Pre-/post-test or survey difference | 5 | 38.5% |
| Performance assessment | 3 | 23.1% |
| Self-assessment | 3 | 23.1% |
| Journals | 1 | 7.7% |
| Learning styles | 1 | 7.7% |
| Kolbe Learning Styles Inventory | 1 | 7.7% |
| Focus groups | 1 | 7.7% |
| Interviews | 1 | 7.7% |
| Other: program usage | 1 | 7.7% |
| Course evaluations | 1 | 7.7% |
| Observations | 1 | 7.7% |

Under the subcategory *Student Retention*, retention rate was used to evaluate interventions in five of the thirteen studies (38.5%). Continuing in the subject for a career or graduate education was used in one study and coded in as "other" (See Table 14b).

### Table 14b. Method of Evaluation: Student Retention

| **Method of Evaluation** | **Number of Articles** | **Percent of all articles** |
|---|---|---|
| Student Retention | | |
| Retention rate | 5 | 38.5% |

| | | |
|---|---|---|
| Other: continuing in subject for grad school or career | 1 | 7.7% |

Finally, Question 13 examined the outcomes of the interventions. The most commonly coded outcome categories were academic achievement and retention with each appearing in eight of the thirteen studies (61.5%). Attitude was included in six of the thirteen articles (46.2%), and the category of confidence was found at the same rate (46.2%). Five outcome categories (38.5%) were coded as "other." These categories are program satisfaction in three articles, interest in the subject in one article, and program flexibility, also in one article. The outcome categories of student learning and teams were the next most common codes, each being part of four articles (30.8%). Several other outcome categories were included in the thirteen articles in this report. See Table 15 for the full list of outcome categories and their frequencies.

Outcomes were coded based on four possible impacts: *performance enhanced, performance not enhanced, performance declined,* or *inconclusive.* Almost two-thirds of the 69 outcomes were coded as *performance enhanced* (59.4% of all outcomes). Seven of the 69 outcomes (10.1% of all outcomes) were coded as *performance not enhanced*. Six of the outcomes (8.7% of all outcomes) were coded as *performance declined,* and six of the outcomes were coded as *inconclusive.* See Table 15 for complete information on how each outcome was coded.

## Table 15. Outcomes

| Outcome | Number of Articles | Percent of all articles | Number of all articles | | | |
|---|---|---|---|---|---|---|
| | | | Performance enhanced | Performance not enhanced | Performance declined | Inconclusive |
| Academic Achievement | 8 | 61.5% | 5 | 2 | | 1 |
| Retention | 8 | 61.5% | 1 | | | 2 |
| Major | 3 | 23.1% | 3 | | | |
| College/univesity | 1 | 7.7% | 1 | | | |
| Course | 1 | 7.7% | 1 | | | |
| Attitude | 6 | 46.2% | 2 | 1 | | |
| Positive Attitude | 3 | 23.1% | 3 | | | |
| Confidence | 6 | 46.2% | 4 | 1 | 1 | |
| Other | 5 | 38.5% | 4 | | 1 | |
| Student Learning | 4 | 30.8% | 3 | | | 1 |
| Teams | 4 | 30.8% | 3 | | 1 | |
| Laboratory skills/research skills | 3 | 23.1% | 2 | 1 | | |
| Motivation | 3 | 23.1% | 1 | 1 | 1 | |
| Higher order thinking skills | 3 | 23.1% | 2 | | 1 | |
| Engagement | 2 | 15.4% | 1 | | 1 | |
| Problem Solving Skills | 2 | 15.4% | 1 | 1 | | |
| Retention of material | 2 | 15.4% | 1 | | | 1 |
| Communication skills | 2 | 15.4% | | | | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Oral Communication | 1 | 7.7% | 1 | | | |
| Written communication | 1 | 7.7% | 1 | | | |
| Professional skills | 1 | 7.7% | 1 | | | |
| **Total number of outcomes** | **69** | | **41** | **7** | **6** | **6** |
| **Percent of all outcomes** | | | **59.4%** | **10.1%** | **8.7%** | **8.7%** |

# APPENDIX B: Individual Coding Data Sheets

## DATASHEET (EXAMPLE)

## Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author:** ______________________________________________________ **Year** _________

**Title:** _______________________________________________________________________

**Source:** _____________________________________________________________________

**Volume:** _________ **Number:** _______ **Pages:** ____________________

2. **Content/Subject Area**

***Engineering major****

general/introduction

aerospace engineering

agricultural engineering

architectural engineering

bioengineering and biomedical engineering

ceramic engineering

chemical engineering

civil engineering

computer engineering

construction engineering

electrical engineering

electronic engineering

engineering management

environmental engineering

geological engineering

industrial engineering

manufacturing engineering

materials and metallurgical engineering

mechanical engineering

mining engineering

naval architecture and marine engineering

nuclear and radiological engineering

ocean engineering

petroleum engineering

software engineering

surveying

other: ________________

***Engineering fundamentals****

Dynamics

Chemistry

Computers, measurement, and controls

Electric circuits

Engineering economics

Ethics

Fluid mechanics

Heat transfer

Materials science/structure of matter

Mathematics and statistics

Mechanics of materials

Statics

Thermodynamics

Transport phenomena

***Design***

***Laboratories & laboratory courses***

- ***Other sciences****
  - biology
  - computer science
  - geology
  - geophysics
  - physics
  - science (general)
  - technology
  - other: ___________
- ***Social sciences***
  - Business
  - Economics
  - Psychology
  - Sociology
  - Specify: ______________
- ***Humanities***
- English
- History of Science/Technology or Science, Technology, and Society
- Technical writing
- ***Other:*** ___________
- ***Not specified***

**3.a/ Population**

- Faculty
- General population of students
- Specific populations of students
  - Gender*
    - Male
    - Female
  - Underrepresented minority
    - Race*
      - White
      - Black
      - Asian
      - Native American
      - Pacific Islander
      - Other: ______________
    - Ethnicity*
      - Hispanic
      - Non-Hispanic
      - Ethnic minority (general)
      - Other: ______________
  - Disability*
    - Hearing
    - Physical
    - Psychological/emotional
    - Visual
    - Other: _____________
  - At-risk/high-risk
- Not specified

3.b **Location of the study**

- United States
- Outside the United States

4. **Sample size**

- Number of subjects
  - 1 – 10
  - 11- 25
  - 26-50
  - 51-100
  - More than 100

    - Not specified

5.a. **Type of Institution**

- Four year
    - Doctoral/Research
    - Masters
    - Baccalaureate
    - Special Engineering
    - Special Other
    - No institutional code
- Two year
- Foreign

5.b. **Social arrangement**

- Individual
- Pairs
- Small group
- Team
- Whole class
- Cluster
- Other: _______________
- Not specified

**6. Locus of application**

- Individual
- Tutorial/workshop
- Section
- Outside the classroom
- Classroom/course
- Laboratory
- Studio
- Program
- Department
- Institution/college/university
- State system
- Consortium of universities
- Business/industry
- Community
- Other: ____________________
- Not specified

7. **Level**

- Rising freshmen
- Freshman
- Sophomore
- Junior
- Senior*
    - Capstone course
- Graduate students
- Faculty
- Other ______________
- Not specified

8. **Theory**

- Behavioral
    - Human motor behavior
    - Self-paced learning/Keller
    - Other: ____________________
- Bloom's taxonomy
- Cognitive/Constructivist/Social Constructivist
    - Cognitive apprenticeship model
    - Other: ___________________________
- Learning Styles
    - Kolb

    - Other: ________________________
  - Emancipatory (e.g., feminist, gender): _____________________________
  - Personality
  - Other: _______________________________
  - No theory
  - Not specified

9. **Nature of Research**

  - Action Research
  - Anecdotal
  - Case Study
  - Comparison groups
  - Experimental*
    - Experimental with control groups
    - Random sample
    - Random assignment to groups
  - Longitudinal
  - Meta-analysis
  - Pre-/post-test or survey
  - Qualitative
  - Quantitative
  - Other: ________________________
  - Not specified

10.a. **Duration of intervention**

  - Amount of time*
    - One class period
    - Less than a week
    - One week
    - Two to three weeks
    - One month
    - More than one month but less than a term
    - One term (e.g., semester, quarter, session)
    - One academic year
    - More than one academic year but less than the entire program
    - Entire program
  - Number of interventions*
    - Short, one-time interventions of less than a term (e.g., one session, laboratory, module, problem, unit, project,)
    - Multiple interventions over the course of a term
  - Other: ___________________
  - Not specified

**10.b Duration of the study**

  - Less than a term
  - One term
  - One academic year/two semesters
  - Two academic years
  - Three academic years
  - More than three academic years
  - Other: ______________________
  - Not specified

11. **Practice in Engineering Education related to:**

  - ***Teaching and learning****
    - Active learning
    - Case studies
    - Collaborative/cooperative learning
    - Concept Inventories

- Concept maps
- Contests
- Debate
- Demonstration
- Faculty/student interaction
- Games
- Independent research
- Inquiry/discovery/hands-on
- Integrated curriculum
- Interactive voting system
- Journals
- Laboratory (traditional)
- Laboratory (reformed)
- Learning styles
- Lecture (traditional)
- Lecture (active)
- Peer review/teaching
- Personalized system of instruction
- Presentation
- Problem-based
- Problem solving
- Projects / project-based
- Role-playing
- Self-paced instruction
- Studio approach
- Supplementary instruction
- Teams
  - Cross-functional
  - Multidisciplinary
  - Vertically integrated
  - Virtual
- Think-pair-share
- Tutorial
- Other:_________________

***Educational technology****

- Animation
- Hypertext/hypermedia
- Interactive
- Simulation
- Multimedia
- Software packages
  - Computation tools
    - Matlab
    - Excel
  - Design tools
  - Visualization tools
- Tutorial
- Video
- Virtual reality
- Visualization/visual techniques
- Other:_________________

***Communication and information Technology****

- Asynchronous
- Distance learning
- Distributed
- Online discussion/community
- Online course content
- Online video
- Synchronous
- Web-based

- Other:_________________

***Development of professional skills****

- Case studies
- Co-op
- Intern
- Management skills
- Simulated companies
- Teams
- Other:_________________

***Student assessment****

- Concept inventories
- Goals
- Journals
- Peer assessment
- Performance assessment
- Portfolios
- Reflective writing
- Rubrics
- Self-assessment
- Other:_________________

***Student retention****

- Clustered courses
- Common course scheduling
- Communal housing
- Faculty development
- Faculty mentoring
- Learning communities
- Mentoring
  - Peer mentoring
- Orientation program
- Professional speakers
- Research internships
- Site visits
- Skill enhancement
- Student community
- Supplementary/remedial coursework
- Team work
- Other: _______________

***Other:* ______________________**

***Not specified***

**12. Method of Assessing the Practice**

**Practice**

***Teaching/learning (includes educational, communicate, and information technology, and development of professional skills)****

- Academic performance*
  - Achievement test
  - Exams*
    - Essay
    - Oral
    - Multiple choice
    - Written
  - GPA
  - Grades
  - Homework/assignments
  - Quizzes

***Student assessment****

- *{need more data in order to expand}*
- Other: _______________________
- Not specified

***Student retention****

- Attrition rate
- Retention rate
- Registration status
- Graduation status
- Other: ________________________
- Not specified

**Other: __________________**

**Not specified**

- Concept inventories
- Course evaluations
- Design notebooks
- Documents
- External evaluation
- Focus groups
- Journals
- Interviews
- Inventories*
  - Force Concept Inventory
  - Mechanics Baseline Test
  - Wave Concept Inventory
  - Other: ____________
- Learning styles*
  - Contrasted Groups Learning Styles Questionnaire
  - Felder-Silverman Learning Style Model
  - Kolbe Learning Styles Inventory
  - Myers-Briggs Type Indicator
  - Other: ________________________
- Meta-analysis
- Observation
- Peer assessment
- Performances
- Performance assessment
- Portfolios
- Presentations
- Pre-/post-test or survey difference
- Projects
- Reports
- Rubrics
- Student comments/feedback/reflections
- Self-assessment
- Surveys/questionnaires
  - Alumni Survey
- Team grade and individual grade on team projects

Other: ______________

Not specified

**14. Meta analysis Y N**

**13. Outcome**
**Attitude***

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Change in attitude**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Positive attitude**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Academic achievement**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Communications skills***

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Oral**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Written**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Creative thinking**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome*: ________________________

**Design skills**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Engagement**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Higher order thinking skills**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Student learning**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Laboratory skills/Research skills**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Problem solving skills**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Professional skills**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Retention***

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Course**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Major**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**College/University**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Teams***

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Team learning**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Team skills**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Utility of assessment instrument***

- *performance enhanced (useful)*
- *performance not enhanced*
- *performance declined (not useful)*
- *inconclusive*

**Student learning**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

**Knowledge about student progress**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Ethics/Moral reasoning**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Retention of material**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Confidence**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Motivation**

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

**Other** _________________________

- *performance enhanced*
- *performance not enhanced*
- *performance declined*
- *inconclusive*

*Outcome:* ______________________

# DATASHEET

## Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Bernold, Leonhard E., Joni E. Spurlin, and Chris M. Anson **Year:** 2007

**Title:** Understanding Our Students: A Longitudinal-Study of Success and Failure in Engineering with Implications for Increased Retention

**Source:** *Journal of Engineering Education*

**Volume:** 96 **Number:** 3 **Pages:** 263-27

---

2. **Content/Subject Area**

- ***Engineering major***
  - general/introduction

3.a **Population**

- General population of students

3.b **Location of the study**

- United States

4. **Sample Size**

- Number of Subjects
  - More than 100

5.a **Type of Institution**

- Four year

5.b **Social Arrangement**

- Whole class

6. **Locus of Application**

- Individual
- Classroom/course

7. **Level**

- Freshman

8. **Theory**

- Learning styles
  - Kolb

9. **Nature of Research**

- Longitudinal
- Quantitative

10.a **Duration of Intervention**

- One term

10.b **Duration of the study**

- Three academic years

11. **Practice in Engineering Education related to:**

- ***Teaching and learning***
  - Learning styles
  - Lecture (traditional)
  - Problem solving

12. **Method of Assessing the Practice**

- ***Teaching/Learning***
  - Academic performance
    - GPA
  - Journals
  - Learning styles
    - Kolbe Learning Styles
      - Inventory
  - Surveys/questionnaires
- ***Student retention***
  - Retention rate

14. **Meta Analysis** **N**

13. **Outcome**

- **Academic Achievement**
  - *-inconclusive*
- **Student learning**
  - *-inconclusive*
- **Retention**
  - *-inconclusive*

## DATASHEET

### Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author**: Grimberg, Stefan J., et al. **Year**: 2008

**Title**: A Theme-Based Seminar on Environmental Sustainability Improves Participant Satisfaction in an Undergraduate Summer Research Program

**Source**: *Journal of Engineering Education*

**Volume:** 97 **Number:** 1 **Pages:** 95-103

---

**2. Content/Subject Area**

- Engineering major
  - Environmental engineering

**3.a Population**

- Specific populations of students
  - Gender
  - Underrepresented minority

**3.b Location of the study**

- United States

**4. Sample Size**

- Number of Subjects
  - 51-100

**5.a Type of Institution**

- Four year

**5.b Social Arrangement**

- Whole class

**6. Locus of Application**

- Program

**7. Level**

- Junior
- Senior

**8. Theory**

- Not specified

**9. Nature of Research**

- Longitudinal
- Pre-/post-test or survey
- Quantitative

**10.a Duration of Intervention**

- Entire program

**10.b Duration of the study**

- More than three academic years

**11. Practice in Engineering Education related to:**

- Teaching and learning
  - Presentation
  - Projects/project-based
  - Supplementary instruction
- Student retention
  - Mentoring
  - Site visits
  - Student community

**12. Method of Assessing the Practice**

- Teaching/Learning

Pre-/post-test or survey difference
Student comments/feedback/reflections

- Student retention
  - Other: continuing in subject for

grad school or career

**14. Meta Analysis N**

**13. Outcome**

- Retention
  - -inconclusive
- Other: program satisfaction
  - -performance enhanced

## DATASHEET

### Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author:** Hartman, Harriet and Moshe Hartman **Year:** 2007

**Title:** Leaving Engineering: Lessons from Rowan University’s College of Engineering

**Source:** *Journal of Engineering Education*

**Volume:** 95 **Number:** 1 **Pages:** 49-61

---

2. **Content/Subject Area**

*Engineering major*

- general/introduction
- chemical engineering
- civil engineering
- electrical engineering
- mechanical engineering

3.a **Population**

General population of students

3.b **Location of the study**

United States

4. **Sample Size**

Number of Subjects

More than 100

5.a **Type of Institution**

Four year

Special engineering

5.b **Social Arrangement**

Whole class

6. **Locus of Application**

- Classroom/course
- Program
- Department
- Institution/college/university

7. **Level**

- Freshman
- Sophomore
- Junior
- Senior

8. **Theory**

Learning Styles

9. **Nature of Research**

- Comparison groups
- Pre-/post-test survey
- Longitudinal
- Quantitative

10.a **Duration of Intervention**

Entire program

10.b **Duration of the study**

Two academic years

11. **Practice in Engineering Education related to:**

***Teaching and learning***

- Faculty/student interaction
- Inquiry/discovery/hands-on
- Integrated curriculum
- Projects/project-based
- Teams

***Student Retention***

- Common course scheduling
- Mentoring
- Team work

12. **Method of Assessing the Practice**

***Teaching/Learning***

- Academic achievement
  - GPA
- Pre-/post-test or survey
  - Difference
- Student comments/feedback/reflections

***Student retention***

- Retention rate

14. **Meta Analysis** **N**

13. **Outcome**

**Retention**

**Major**

*-performance enhanced*

## DATASHEET

### Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Hartman, Harriet and Moshe Hartman **Year:** 2006

**Title:** Undergraduate Women's Participation in Professional Organizations

**Source:** *Journal of Women and Minorities in Science and Engineering*

**Volume:** 11 **Number:** 1 **Pages:** 117-137

---

2. **Content/Subject Area**

    ***Engineering major***

        Chemical engineering
        Civil engineering
        Computer engineering
        Electrical engineering
        Mechanical engineering

3.a **Population**

    Specific population of students

        Gender

            Female

3.b **Location of the study**

    United States

4. **Sample Size**

    Number of Subjects

        51-100

5.a **Type of Institution**

    Four year

5.b **Social Arrangement**

    Small group

6. **Locus of Application**

    Individual

    Outside the classroom

    Other: <u>professional organization</u>

7. **Level**

    Not specified

8. **Theory**

    Not specified

9. **Nature of Research**

    Pre-/post-test or survey

    Comparison groups

10.a **Duration of Intervention**

    Amount of time

        One academic year

10.b **Duration of the study**

    One academic year/two semesters

11. **Practice in Engineering Education related to:**

    ***Teaching and learning***

        Faculty/student interaction
        Tutorial

    ***Development of professional skills***

        Other: <u>participation in professional organizations</u>

    ***Student retention***

        Peer mentoring
        Team work

12. **Method of Assessing the Practice**

    ***Teaching/Learning***

        Pre-/post-test or survey

            Difference

        Student comments/feedback/reflections

        Surveys/questionnaires

14. **Meta Analysis** **N**

13. **Outcome**

    **Attitude**

        **Positive attitude**

        *-performance enhanced*

    **Academic achievement**

        *-performance enhanced*

    **Engagement**

        *-performance enhanced*

    **Laboratory skills/ Research skills**

        *-performance not enhanced*

    **Retention**

        **Major**

        *-performance enhanced*

        **College/University**

        *-performance enhanced*

**Confidence**

*-performance enhanced*

**Other: <u>satisfaction with program</u>**

*-performance enhanced*

# DATASHEET

## Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author:** Kahveci, Ajda, Sherry A. Southerland, and Penny J. Gilmer **Year:** 2006

**Title:** Retaining Undergraduate Women in Science, Mathematics, and Engineering

**Source:** *Journal of College Science Teaching*

**Volume:** 36 **Number:** 3 **Pages:** 34-38

---

2. **Content/Subject Area**

*__Other Sciences__*

Science (general)

3.a **Population**

Specific populations of students

Gender

Female

3.b **Location of the study**

United States

4. **Sample Size**

Number of Subjects

51-100

5.a **Type of Institution**

Four year

Doctoral/Research

5.b **Social Arrangement**

Team

6. **Locus of Application**

Outside the classroom
Classroom/course

7. **Level**

Freshman

8. **Theory**

Not specified

9. **Nature of Research**

Comparison groups
Pre-/post-test or survey
Qualitative
Quantitative

10.a **Duration of Intervention**

Amount of time

Entire Program

10.b **Duration of the study**

One academic year/two semesters

11. **Practice in Engineering Education related to:**

*__Teaching and learning__*

Faculty/student interaction

*__Student Retention__*

Common course scheduling
Communal housing
Learning Communities
Mentoring
Professional speakers
Research internships
Site visits
Supplementary/remedial coursework

12. **Method of Assessing the Practice**

*__Teaching/learning__*

Academic performance
GPA
Pre-/post-test or survey difference
Surveys/questionnaires

*__Student retention__*

Retention rate

14. **Meta Analysis** **N**

13. **Outcome**

**Academic achievement**

*-performance not enhanced*

**Retention**

*-performance enhanced*

**Major**

*-performance enhanced*

**Confidence**

*-performance not enhanced*

**Other:** *Interest in subject*

*-performance declined*

## DATASHEET

## Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author:** McShannon, J., et al. **Year:** 2006

**Title:** Gaining Retention and Achievement for Students Program: A Faculty Development Program

**Source:** *Journal of Professional Issues in Engineering Education and*

**Volume:** 132 **Number:** 3 **Pages:** 204-208

---

2. **Content/Subject Area**

*Engineering major*

General/introduction

3.a **Population**

Faculty

3.b **Location of the study**

United States

4. **Sample Size**

Number of Subjects

51-100

5.a **Type of Institution**

Four year

5.b **Social Arrangement**

Individual

6. **Locus of Application**

Individual

7. **Level**

Faculty

8. **Theory**

Not specified

9. **Nature of Research**

Pre-/post-test or survey

Quantitative

Comparison groups

10.a **Duration of Intervention**

One term

10.b **Duration of the study**

More than three academic years

11. **Practice in Engineering Education related to:**

***Teaching and learning***

Faculty/student interaction
Lecture (traditional)
Lecture (active)
Peer review/teaching
Personalized system of instruction

***Student Retention***

Faculty development

12. **Method of Assessing the Practice**

***Teaching/Learning***

Academic performance

Grades

Surveys/questionnaires

***Student retention***

Retention rate

14. **Meta Analysis** **N**

13. **Outcome**

**Academic achievement**

*-performance enhanced*

**Retention**

**Course**

*-performance enhanced*

## DATASHEET

### Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Micari, Marina and Denise Drane **Year:** 2007

**Title:** Promoting Success: Possible Factors Behind Achievement of Underrepresented Students in a Peer-Led Small-Group STEM Workshop Program

**Source:** *Journal of Women and Minorities in Science and Engineering*

**Volume:** 13 **Number:** 3 **Pages:** 295-315

---

2. **Content/Subject Area**
   - ***Engineering major***
     - General/introduction

3.a **Population**
   - General population of students

3.b **Location of the study**
   - United States

4. **Sample Size**
   - Number of Subjects
     - 26-50

5.a **Type of Institution**
   - Four year

5.b **Social Arrangement**
   - Small group

6. **Locus of Application**
   - Tutorial/workshop

7. **Level**
   - Sophomore

8. **Theory**
   - No theory

9. **Nature of Research**
   - Qualitative
   - Quantitative

10.a **Duration of Intervention**
   - Amount of time
     - One academic year

10.b **Duration of the study**
   - Three academic years

11. **Practice in Engineering Education related to:**
   - ***Teaching and learning***
     - Peer review/teaching
     - Problem-based
     - Supplementary instruction
     - Teams
   - ***Student retention***
     - Mentoring
       - Peer mentoring
     - Supplementary/remedial coursework

12. **Method of Assessing the Practice**
   - ***Teaching/Learning***
     - Academic performance
       - Grades
     - Focus groups
     - Interviews
   - ***Student retention***
     - Retention rate

14. **Meta Analysis** **N**

13. **Outcome**
   - **Academic achievement**
     - *-performance enhanced*
   - **Student learning**
     - *-performance enhanced*
   - **Retention**
     - *-performance enhanced*
   - **Teams**
     - *-performance enhanced*
   - **Confidence**
     - *-performance enhanced*
   - **Other:** **Satisfaction**
     - *-performance enhanced*

## DATASHEET

## Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Read, Elizabeth, Ben Hanson, and Martin Levesley **Year:** 2008

**Title:** Using Weblabs as a Tool to Support a Culturally Diverse Student Cohort

**Source:** *Engineering Education*

**Volume:** 3 **Number:** 1 **Pages:** 52-61

---

2. **Content/Subject Area**
    - ***Engineering major***
        - Mechanical engineering

3.a **Population**
    - General population of students

3.b **Location of the study**
    - Outside the United States

4. **Sample Size**
    - Number of Subjects
        - Not specified

5.a **Type of Institution**
    - Foreign

5.b **Social Arrangement**
    - Small group

6. **Locus of Application**
    - Individual
    - Outside the classroom

7. **Level**
    - Sophomores
    - Junior

8. **Theory**
    - Not specified

9. **Nature of Research**
    - Comparison groups
    - Qualitative
    - Quantitative

10.a **Duration of Intervention**
    - Number of interventions
        - Multiple interventions over the course of a term

10.b **Duration of the study**
    - One term

11. **Practice in Engineering Education related to:**
    - ***Teaching and learning***
        - Inquiry/discovery/hands-on
        - Laboratory (reformed)
    - ***Educational technology***
        - Interactive
    - ***Communication and information technology***
        - Distance learning
        - Online course content
        - Web-based
    - ***Student retention***
        - Team work

12. **Method of Assessing the Practice**
    - ***Teaching/Learning***
        - Performance assessment
        - Student comments/ feedback/reflections
        - Other: program usage

14. **Meta Analysis** **N**

13. **Outcome**
    - **Attitude**
        - **Positive attitude**
            - *-performance enhanced*
    - **Academic Achievement**
        - *-performance not enhanced*
    - **Laboratory skills/ Research skills**
        - *-performance enhanced*
    - **Teams**
        - *-performance enhanced*
    - **Other: program flexibility**
        - *-performance enhanced*

## DATASHEET

## Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author:** Reisslein, Jane, Howard Sullivan, and Martin Reisslein **Year:** 2007

**Title:** Learner Achievement and Attitudes under Difference Paces of Transitioning to Independent Problem Solving

**Source:** *Journal of Engineering Education*

**Volume:** 96 **Number:** 1 **Pages:** 45-55

---

2. **Content/Subject Area**

    ***Engineering major***

        General/introduction

    ***Engineering fundamentals***

        Electric circuits

3.a **Population**

    General population of students

3.b **Location of the study**

    United States

4. **Sample Size**

    Number of Subjects

        More than 100

5.a **Type of Institution**

    Four year

5.b **Social Arrangement**

    Small group

6. **Locus of Application**

    Individual

7. **Level**

    Freshman

8. **Theory**

    Cognitive/Constructivist/Social constructivist

9. **Nature of Research**

    Comparison groups

    Experimental

    Pre-/Post-test or survey

10.a **Duration of Intervention**

    Number of interventions

        Short, one-time interventions of less than one term

10.b **Duration of the study**

    Less than a term

11. **Practice in Engineering Education related to:**

    ***Teaching and learning***

        Problem solving

        Self-paced instruction

    ***Educational technology***

        Interactive

12. **Method of Assessing the Practice**

    ***Teaching/Learning***

        Academic performance

            Achievement test

        Pre-/post-test or survey difference

14. **Meta Analysis** **N**

13. **Outcome**

    **Attitude**

        *-performance enhanced*

    **Problem solving skills**

        *-performance not enhanced*

    **Retention of Material**

        *-inconclusive*

    **Motivation**

        *-performance declined*

## DATASHEET

## Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Roselli, Robert J. and Sean P. Brophy Anson **Year:** 2006

**Title:** Effectiveness of Challenge-Based Instruction in Biomechanics

**Source:** *Journal of Engineering Education*

**Volume:** 95 **Number:** 4 **Pages:** 311-324

---

2. **Content/Subject Area**

    ***Engineering major***

        Bioengineering and biomedical engineering

3.a **Population**

    General population of students

3.b **Location of the study**

    United States

4. **Sample Size**

    Number of Subjects

        More than 100

5.a **Type of Institution**

    Four year

5.b **Social Arrangement**

    Whole class

6. **Locus of Application**

    Classroom/course

7. **Level**

    Sophomore

8. **Theory**

    Learning styles

9. **Nature of Research**

    Experimental

        Experimental with control groups

    Pre-/post-test survey

    Quantitative

10.a **Duration of Intervention**

    Amount of time

        One term

10.b **Duration of the study**

    More than three academic years

11. **Practice in Engineering Education related to:**

    ***Teaching and learning***

        Active learning
        Lecture (active)
        Problem-based
        Other: challenge-based

    ***Educational technology***

        Tutorial

    ***Communication & information technology***

        Online course content

    ***Student retention***

        Supplementary/remedial coursework

12. **Method of Assessing the Practice**

    ***Teaching/Learning***

        Academic Performance

            Exams

        Course evaluations
        Observation
        Performance assessment
        Student comments/feedback/reflections
        Surveys/questionnaires

14. **Meta Analysis** **N**

13. **Outcome**

    **Attitude**

        *-performance enhanced*

    **Higher order thinking skills**

        *-performance enhanced*

    **Student learning**

        *-performance enhanced*

    **Problem solving skills**

        *-performance enhanced*

    **Retention of material**

        *-performance enhanced*

    **Motivation**

        *-performance not enhanced*

## DATASHEET

## Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Thompson, Nancy S., et al. **Year:** 2005

**Title:** Integrating Undergraduate Research into Engineering: A Communications Approach to Holistic Education

**Source:** *Journal of Engineering Education*

**Volume:** 94 **Number:** 3 **Pages:** 297-307

---

2. **Content/Subject Area**

*__Engineering major__*
- Chemical engineering
- Electrical engineering
- Mechanical engineering

3.a **Population**

General population of students

3.b **Location of the study**

United States

4. **Sample Size**

Number of Subjects

26-50

5.a **Type of Institution**

Four year

5.b **Social Arrangement**

Small group

6. **Locus of Application**

Studio

7. **Level**

- Freshman
- Sophomore
- Junior
- Senior

8. **Theory**

- Bloom's taxonomy
- Cognitive/Constructivist/ Social

Constructivist

9. **Nature of Research**

- Anecdotal
- Pre-/post-test or survey
- Qualitative
- Quantitative

10.a **Duration of Intervention**

Amount of time

More than one academic year but less than the entire program

10.b **Duration of the study**

Two academic years

11. **Practice in Engineering Education related to:**

*__Teaching and learning__*
- Active learning
- Faculty/student interaction
- Independent research
- Inquiry/discovery/hands-on
- Journals
- Presentation
- Studio approach
- Teams

*__Student assessment__*
- Goals
- Reflective writing
- Self-assessment

*__Student retention__*
- Mentoring
- Skill enhancement

12. **Method of Assessing the Practice**

*__Teaching/Learning__*
- Performance assessment
- Student comments/feedback/reflections
- Self-assessment
- Surveys/questionnaires

14. **Meta Analysis** **N**

13. **Outcome**

**Attitude**
- **Positive attitude**
  - *-performance enhanced*

**Communications skills**
- **Oral**
  - *-performance enhanced*
- **Written**
  - *-performance enhanced*

**Higher order thinking skills**
- *-performance enhanced*

**Laboratory skills/Research skills**
- *-performance enhanced*

**Professional skills**
- *-performance enhanced*

**Teams**
- *-performance enhanced*

**Confidence**

*-performance enhanced*

## DATASHEET

## Judging the Evidence Base for “Best Practices” in STEM Teaching and Assessment

**Author:** Vogt, Christina M. **Year:** 2007

**Title:** Faculty as a Critical Juncture in Student Retention and Performance in Engineering Programs

**Source:** *Journal of Engineering Education*

**Volume:** 97 **Number:** 1 **Pages:** 27-36

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2. **Content/Subject Area**

***Engineering major***

general/introduction

3.a **Population**

General population of students

3.b **Location of the study**

United States

4. **Sample Size**

Number of Subjects

More than 100

5.a **Type of Institution**

Four year

Doctoral/Research

5.b **Social Arrangement**

Individual

6. **Locus of Application**

Individual

7. **Level**

Freshman
Sophomore
Junior
Senior

8. **Theory**

Cognitive/Constructivist/Social

Constructivist

Other: <u>social cognitive model</u>

9. **Nature of Research**

Pre-/post-test survey
Quantitative

10.a **Duration of Intervention**

Not specified

10.b **Duration of the study**

Less than a term

11. **Practice in Engineering Education related to:**

***Teaching and learning***

Faculty/student interaction

12. **Method of Assessing the Practice**

***Teaching/Learning***

Academic performance

GPA

Self-assessment

Surveys/questionnaires

14. **Meta Analysis** **N**

13. **Outcome**

**Academic Achievement**

*-performance enhanced*

**Confidence**

*-performance enhanced*

# DATASHEET

## Judging the Evidence Base for "Best Practices" in STEM Teaching and Assessment

**Author:** Zhao, Chun-Mei, Robert M. Carini, and George D. Kuh **Year:** 2005

**Title:** Searching for the Peach Blossom Shangri-La: Student Engagement of Men and Women SMET Majors

**Source:** *The Review of Higher Education*

**Volume:** 28 **Number:** 4 **Pages:** 503-525

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2. **Content/Subject Area**

- ***Engineering major***
  - General/introduction

3.a **Population**

- Specific populations of students
  - Gender
    - Female

3.b **Location of the study**

- United States

4. **Sample Size**

- Number of Subjects
  - More than 100

5.a **Type of Institution**

- Four year

5.b **Social Arrangement**

- Individual

6. **Locus of Application**

- Individual

7. **Level**

- Freshman
- Senior
  - Capstone course

8. **Theory**

- Not specified

9. **Nature of Research**

- Experimental
  - Random sample
- Pre-/post-test or survey
- Quantitative

10.a **Duration of Intervention**

- Not specified

10.b **Duration of the study**

- Two academic years

11. **Practice in Engineering Education related to:**

- ***Teaching and learning***
  - Active learning
  - Collaborative/cooperative learning
  - Faculty/student interaction
  - Other: challenge of exams
- ***Student assessment***
  - Performance assessment
  - Other: time spent relaxing
- ***Student Retention***
  - Student community

12. **Method of Assessing the Practice**

- ***Teaching/learning***
  - Self-assessment
  - Surveys/questionnaires

14. **Meta Analysis** **N**

13. **Outcome**

- **Attitude**
  - *-performance not enhanced*
- **Academic achievement**
  - *-performance enhanced*
- **Communication skills**
  - *-inconclusive*
- **Engagement**
  - *-performance declined*
- **Higher order thinking skills**
  - *-performance declined*
- **Student learning**
  - *-performance enhanced*
- **Teams**
  - *-performance declined*
- **Confidence**
  - *-performance declined*
- **Motivation**
  - *-performance enhance*