Int. J. Engng Ed. Vol. 26, No. 5, pp. 1083–1096, 2010
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Creating the Ideas to Innovation Learning Laboratory: A First-Year Experience Based on Research*

TERI REED-RHOADS, P. K. IMBRIE, KAMYAR HAGHIGHI, DAVID F. RADCLIFFE, SEAN BROPHY, MATTHEW W. OHLAND, and ERIC HOLLOWAY
Purdue University, 701 West Stadium Avenue, West Lafayette, IN 47907–2045, USA.
E-mail: trhoads@purdue.edu

Engineering graduates will play a leading role in tackling the major challenges facing society, nationally and globally. Their achievement of this goal will require a broader set of knowledge, abilities, and qualities, which will require schools or colleges of engineering to attract a more diverse and representative cohort of students to study engineering; students who are passionate about making a difference in the world and who collectively are highly creative and imaginative as well as analytical. To achieve these goals—a more diverse student body, motivated and equipped to rise to the challenges ahead—we need a new approach to how we transition this next generation of engineers into our programs of higher education.

Presented in this paper is a new first-year experience that has been conceived and designed to accomplish these goals based upon research. Particular attention was paid to the use of: learning spaces, how students are engaged in the learning process, and the use of learning technologies. The new first-year experience is a strategic response to the numerous calls to action for engineering education published in recent years. Industry has concluded that business as usual will not enable it to meet the challenges and opportunities presented by globalization in an uncertain world. Equally, education as usual will not deliver the graduates that this nation and world need if we are to meet these challenges.

Keywords: first-year; learning spaces; engagement; technology enabled learning; design

1. INTRODUCTION

THE NATIONAL SCIENCE FOUNDATION (NSF) report 'America's Academic Future' [1] concluded that the over-dependence on the standard lecture must be diminished with emphasis given instead to inquiry-based learning through networked, technology-based instruction. Hands-on experience with engineering tools and contexts serve the dual role of both motivating and embellishing topics being taught in the classroom [2–12]. In this spirit, providing students the means by which they can explore and experiment with fundamental concepts is part of an evolving educational paradigm shift in engineering education. Unfortunately, most institutions deliver these kinds of supplementary activities in a separate laboratory course or not at all. Thus, development of an infrastructure that allows students sitting in a classroom to participate in an inquiry-based, hands-on experiment, using real equipment would have an obvious educational value for 'just-in-time' learning. As such we believe there is a compelling need for learner-centered, contextualized, fully interactive, multimedia learning environments for all types of courses, especially for those offered to first-year students.

> Where ideas collide, innovation happens.—*Frans Johansson's, The Medici Effect*

In recognition of these needs, Purdue University's Ideas to Innovation (i2i) Learning Laboratory was created as a unique, flexible space that engages learners of all ages in creating solutions to stimulating, authentic design challenges that require creative and innovative thinking. The i2i places the entire design and innovation process at the center of learning (See Fig. 1). Through the combined use of space, state-of-the-art learning technologies, and advanced fabrication equipment, learners obtain firsthand experience with engineering concepts and contexts and provide the foundation for future exploration and motivation of sophisticated engineering thinking. By synthesizing results from educational research in fields such as student engagement, active-collaborative learning, teamwork, experiential learning, facilities development and recruiting/marketing of the engineering message, faculty and staff created not only a new learning space but the associated courses. The development of the i2i and its associated courses for first-year engineering students will be discussed.

* Accepted 15 October 2009.

Fig. 1. The Ideas to Innovation Learning Laboratory Design Cycle.

2. DISCUSSION

The College of Engineering at Purdue formed the 'Purdue Engineer of 2020' initiative in 2005 with a goal of developing in students 20 attributes essential in 21st-century engineers. The initiative has its foundation in not only the ABET student outcomes [13], but also goes further with attributes such as leadership, entrepreneurship/intrapreneurship, and innovation. The National Academy of Engineering 2004 report 'The Engineer of 2020' [14], was a motivator in this initiative.

Purdue's Engineer of 2020 attributes are focused on developing a Purdue Engineer who will meet our global society grand challenges. These attributes are shown in Table 1. The College is concentrating on the implementation phase. The College's goal is to develop effective practices for classroom instruction and experiential learning opportunities to ensure that, as a whole, our future graduates will possess what we consider to be the key attributes to lead successful careers in this century's academic and industrial environments. Each School is currently evaluating the attributes in terms of its own program and constituent needs to provide educational experiences to cultivate these attributes as appropriate within each School's curriculum.

As a demonstration of the institutional support for successful implementation of this vision, resources from the College are provided to assist Schools in fostering these attributes in their curricula. First, the College began annual 'Engineer of 2020' workshops in August 2005 with a discussion of what it meant to have these attributes led by then President of the National Academy of Engineering, William Wulf. Subsequently, workshops focus on a subset of specific attributes. The 2007 workshop concentrated on innovation, continuous learning, and multidisciplinarity. The 2008 workshop concentrated on leadership, global issues, and ethics. The two most recent workshops held in 2009 and 2010 focused on environment, societal impact, and entrepreneurship. For the focus attributes chosen, leading representatives (knowledgeable in the focus attributes) are invited from academia and industry to attend the workshop and share their experiences in fostering these attributes in the literature or in their own organizations. Showing that the Purdue Engineer of 2020 is a funded mandate, the College has established an 'Engineer of 2020' Seed Grant Program to fund project ideas leading to the development of these attributes at Purdue.

Table 1 indicates all the attributes with those that are being addressed by the course goals in the newly designed first-year curriculum are bolded. In addition, those lacking italics are included in ABET criterion 3 a-k and those that are italicized are beyond ABET's explicitly stated outcomes. Making these attributes more explicit facilitates our design of effective assessments of learning and systematic design of effective pedagogical

Table 1. Future Purdue Engineer of 2020 Attributes

Abilities	Knowledge Areas	Qualities
• ***leadership*** • **teamwork** • **communication** • ***decision-making*** • ***recognize and manage change*** • *work effectively in diverse and multicultural environments* • work effectively in the global engineering profession • *synthesize engineering, business, and societal perspectives*	• science and math • engineering fundamentals • **analytical skills** • **open-ended design and problem solving skills** • **multi-disciplinarity within and beyond engineering** • **integration of analytical, problem solving and design skills**	• ***innovative*** • ***strong work ethic*** • **ethically responsible in a global, social, intellectual and technological context** • *adaptable in a changing environment* • *entrepreneurial and intrapreneurial* • **curious and persistent continuous learners**

approaches (e.g. working backwards models promoted by Wiggins and McTighe [15]).

According to Bransford, et al. [16], optimal student learning can be achieved by: 1) creating a learning environment that centers on the students; 2) establishing a community that promotes collaboration with peers and the instructional team; and 3) facilitating the development of knowledge for individualize learning through hands-on experience with engineering tools and processes to explore authentic engineering problems. Therefore, to help students begin developing Purdue's Engineer of 2020 attributes as well as maximize their leaning, the essential design criteria used to create the i2i Learning Laboratory centered on the

(a) look and utility of the *learning spaces* [2–3, 5–6, 10, 12, 17];
(b) use of *engaged learning* processes and strategies [11–12, 15, 18–23]; and
(c) use of *learning technologies* to enhance students conceptual understanding and metacognitive knowledge [8–11, 24].

These criteria ultimately enabled us to create a first-year engineering course sequence that facilitates open-ended design and problem solving discovery, is interdisciplinary, hands-on and technology rich, is highly visible to observers (including pre-college visitors), is interactive and stimulating, and is carried out in flexible space and a state-of-the-art learning environment.

The final dimension for affective learning environments includes *assessments* for learning. In the i2i Learning Laboratory, this is accomplished through students' engagement in authentic tasks that stimulate questions that are answered through conversations between and with the instructional team. Other automated assessment using technology are being systematically explored and introduced into the environment.

3. LEARNING SPACES

The Neil Armstrong Hall of Engineering showcases the full spectrum of engineering, from nanoscale (materials engineering) to galactic (aeronautical and astronautical engineering), by housing the School of Aeronautics and Astronautics, the School of Materials Engineering, and the country's first School of Engineering Education. With it's approximately 200,000 square feet, the building also houses the Dean of Engineering offices and Engineering Projects in Community Service (EPICS), as well as the Minority Engineering, Women in Engineering, and Future Students Programs. With a goal of creating synergy between educational philosophy and investment, Armstrong Hall is designed to provide the unique educational and research facilities dedicated to teamwork, hands-on learning, community relationships, and interdisciplinary connections between engineering and society necessary for educating the next generation of engineers.

The planning of the 6097-square foot learning space allowed for the progression of curricular change to move away from large, lecture-based courses that were supplemented with small computer laboratory experiences. In the i2i Learning Laboratory, students experience the entire engineering design process (see Fig. 1). The team-focused, collaborative spaces form a physical representation of the design cycle, serving as a constant reminder to students to ask questions and define the goals of success (design criteria), invent potential alternatives, anticipate and plan for a chosen option, build a prototype and test, reflect based on evaluative outcomes and analyses, and refine as needed. Each space is detailed below and shown in Fig. 2:

- The *Classroom Studio* was a part of the original building design and was designed by the faculty of the School of Engineering Education as a collaborative, teaming-friendly space that seats 120 students. It consists of two sets of long, connected tables on each of three tiers. The two tables are designed where the back table is deeper so that students at the front tables can turn around in the completely movable chairs and team with the two persons directly behind them. The room has tablet PCs in the ratio of

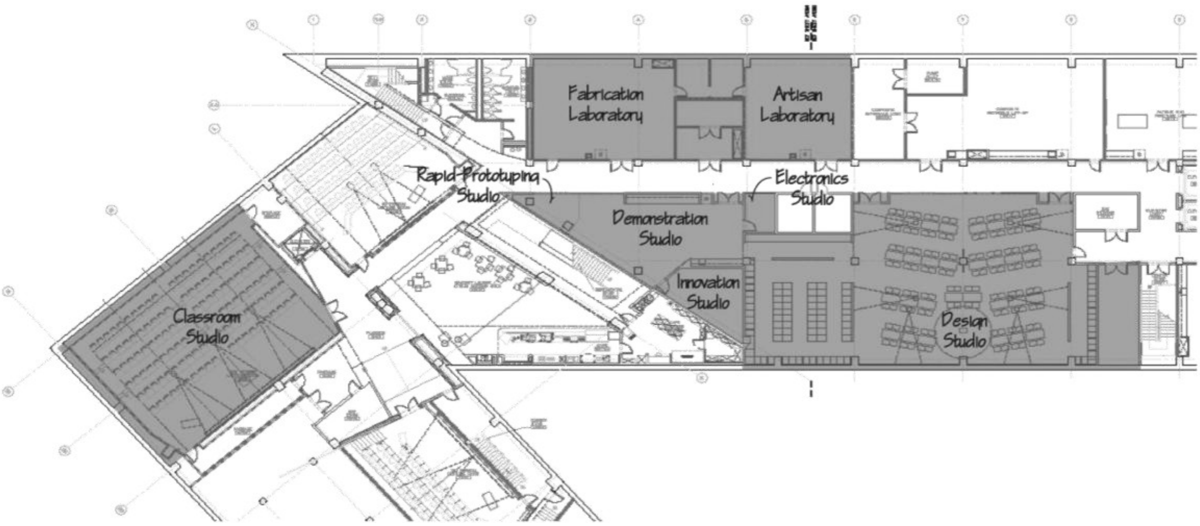

Fig. 2. Architectural Drawing of i2i Space Layout.

one tablet PC to every two students. These are located in baskets attached underneath each table section. There are three projectors across the front of the room along with white boards below the projection area. Therefore, 40 students sit on each tier making ten teams of four students each.

- The *Design Studio* is a media-intensive facility, where students learn the engineering design process, that features built-in flexibility. Floor-to-ceiling 'wall-talkers,' essentially whiteboard wallpaper, cover three walls (the fourth wall is glass), allowing students easy proximity and ample room for writing and sketching as they create solutions to problems. Mobile carts deliver tablet PCs, data acquisition equipment, and other tools to each team's workspace in a just-in-time fashion. Six video projectors positioned around the room allow easy viewing of course material—and can each show different content so that student teams can make mini-presentations to segments of the class simultaneously. As needed, a drop-down partition can divide the 120-student space into two 60-student spaces. Rails at the tops of the walls allow for hanging 2′ by 3′ whiteboards at any point around the room. (These portable whiteboards can be moved to other sections of the i2i Learning Laboratory for continued learning after the formal class period is over.) In addition, each team has its own project storage space so that complex design experiences spanning more than one class period can be developed. See Fig. 3 for the architectural rendering and a recent photo.
- The *Innovation Studio* is an eclectic studio, where making the invisible visible is the theme and students are inspired to think 'outside the box' and explore new concepts. Floor-to-ceiling

Fig. 3. From Architectural Rendering of the Design Studio to Reality with Actual Students in Class.

whiteboard walls and furniture serve as writing/drawing space on which students can craft visual images of their ideas, freed from the boundaries of a piece of paper. Wall-mounted cameras enable students to capture their ideas digitally and send them over the internet to another location. Using a Microsoft Surface™ tabletop touch-screen computer, students can brainstorm together and work interactively with information by combining, editing, and resizing multiple sources of data.

- The *Prototyping Studio* is an environment that enables students to transform their ideas into working prototypes, using 3D printers no larger than a standard copier. Starting with a simple computer-aided design (CAD) drawing, students can go from concept to a physical model—something they can actually touch—in a matter of hours.
- The *Fabrication and Artisan Laboratories* provide students the opportunity to gain hands-on experience building the designs they create in these fully equipped manufacturing facilities. The Fabrication Laboratory houses machining equipment, such as CNC (computer numerical control) lathes and mills and a waterjet cutting system, along with more traditional shop equipment such as welding setups, horizontal and vertical band saws, a drill press, and layout tables where students can begin assembling parts. In the Artisan Laboratory, students work with wood, plastics, and similar materials, using a CNC router, a variety of wood saws, a drill press, and large layout tables.
- The *Demonstration Studio* is a large, open, flexible space where teams of students can gather simultaneously to assemble and demonstrate their projects, using mobile data acquisition equipment and other tools. The glass wall along one side of the room showcases the achievements of Purdue Engineering students to parents, alumni, and visitors. The Demonstration Studio also houses six CAD/CAM stations, where students can design parts to be built in the Fabrication and Artisan Laboratories and generate the programs that run the CNC machines in those labs. At the CAD/CAM stations, students also learn the CNC machine interface and can test their designs by generating simulations of the parts they'll be creating in the CNC machine.
- The *Electronics Studio* is where students can use PC-based data acquisition to gain hands-on experience measuring electrical and physical phenomena such as voltage, current, temperature, pressure, or sound. Electronics-based projects include circuit design, control design and simulation, signal and image processing, fabricating measuring probes, and designing the electrical interface between a measuring probe and a data acquisition system. This studio is equipped with National Instruments' Educational Laboratory Virtual Instrumentation (ELVIS™) educational design and prototyping platform and LabView™. It also houses a large-format plotter for creating CAD drawings and presentation-size posters.

While focusing on preparing the engineers of the future, optimizing the effectiveness of the learning environment is key. We know that it is not just how students are taught; it is also the environment where they learn. Desks nailed to the ground are no longer acceptable learning conditions [5–6]. In fact, learning in an environment similar to the work environment allows students to hit-the-ground-running because they are aware of the conditions of applicability for the knowledge they have gained [25]. Fig. 3 above shows the architectural rendering that was created in the design phase compared to an actual day in the Design Studio. The ability to achieve the vision is demonstrated by the difficulty to tell the difference in the two graphics.

4. ENGAGED LEARNING

We shape our buildings . . . after that; our buildings shape us—*Sir Winston Churchill*

As Sir Winston Churchill stated, once the building is built there are many further opportunities that arise. In this case, it was the change in the curriculum and pedagogy. There has been a large effort in the last decade to understand student learning in technical subjects. Pedagogical research provided a fundamental building block that guided the design of the i2i Learning Laboratory. Research shows that cooperative and collaborative approaches to instruction will enhance learning in general [18, 26–28], and, specifically, faculty are more likely to use active forms of teaching and learning if they are in an environment that encourages multidisciplinary collaboration and team work [29]. According to the National Research Council, learning must connect to other fields of inquiry through practical applications related to the students' experience [30]. By creating these mental 'stepping stones,' students will more readily realize the applicability of knowledge from one context to the next [29]. As new material fits into these existing cognitive structures, the motivational and learning benefits will include providing context, establishing relevance, and teaching inductively. Finally, we have incorporated learning strategies that have proven successful in helping students adopt a 'deep', as opposed to superficial, approach to learning, resulting in learning with understanding [31–32]. Ultimately, the approach to engagement taken in the i2i lab builds on this prior work, particularly from physics education research [17, 19–22, 33–44].

Historically, students were taught in lecture sections of 450 students for two hours a week which then broke down into sections of 30 in computer laboratories for an additional 2 hours a week. The move into the new facility allowed for a shift to the Classroom Studio for two hours a week with a cohort of 120 students and an additional 2 hours a week in the Design Studio with the same cohort and in the same teams. The team-focused design of these two spaces allows for teams to work together in both spaces in a hands-on, collaborative environment. The Honors students, who are approximately 10 to 15% of the overall Purdue engineering first-year student body, were historically taught in sections of 220 with similar times between the lecture hall and computer laboratories but are now taught in sections of 60. The Honors students spend the 2 hours a week in the Design Studio and 2 hours a week in the Classroom Studio with the same cohort and in the same teams.

The context of the technical subjects has to be changed if we are to truly change the face of engineering to be inclusive of diverse persons. Based on the research published by the National Academy of Engineering (NAE) on the discussion of understanding engineering as a field [45], the contextual setting of the course has shifted to the NAE's Grand Challenges [46], where the societal implications of our future engineering challenges are front and center. Using these grand challenges in combination with the successful Model Eliciting Activities (MEAs) led us to our new approach of Engineering Eliciting Activities (EEAs). MEA's are mathematical modeling exercises intended to develop students' higher order understandings that lead to solutions [23, 47–48]. By extension, EEA's are activities that use modeling tasks designed to elicit and develop students understanding of authentic open-ended real-world engineering problems.

As an example of what the context of an EEA might look like, the following brief description is provided—On the Grand Challenge of Carbon Sequestration: Developing an Autonomous Robot for use in a Mobile Thermal Depolymerization Plant. For this particular EEA, students are required to design a prototype mover robot (PMR) that can be transported to a region of the world recently devastated by a natural disaster. Said robot will be prototyped using an NXT-Lego™ robot kit having the following characteristics: 1) walk rather than roll; 2) follow a closed-loop and circuitous path; 3) follow the path to pick up and autonomously determine the contents of a bin of shredded material; 4) move the bin of shredded material from the shredder hopper to the correct location based upon its material type; and 5) automatically return to the separator/shredder station after depositing the bin it was carrying at the appropriate location (i.e., following the closed-looped path back to where it picked up the previous bin). The full EEA description is available from Dr. Imbrie and provides the students with a complete background, a narrative of the project clients, as well as an overview of the project deliverable.

5. LEARNING TECHNOLOGIES

New technological innovations have the potential to enhance the classroom experience beyond chalk and talk including: computer projection systems, high fidelity simulations, laptop computers that improve students' access to information, and the use of rapid prototyping that can turn innovative ideas into physical reality [7–12]. Today's emerging technologies can facilitate new pedagogy, assessments for learning (formative assessments), and other methods that center on the needs of each student learner for improved understanding of the specific knowledge and leveraging factors of social cognition (i.e., community) [24]. An important goal is to develop a physical and cyber infrastructure where students analyze, research, and develop their ideas into something tactile and testable. For example, rapid-prototyping technologies have an obvious educational value for inquiry-based, hands-on, learning, because it provides students tangible feedback on the appropriateness of their ideas [49–51]. These physical prototypes make their thinking visible and shareable with others. Therefore, we believe engaging students through this level of the design process further strengthens their understanding of the process and their ability to guide their own process in future academic and professional context. As such, we believe there is a compelling need for learner-centered, contextualized, fully interactive, concrete, multimedia learning environments for all types of courses, especially for those offered to first-year students.

Establishing our physical and cyber infrastructure centers for supporting all first-year students centers on the Design and Classroom Studios. As mentioned earlier, the basic infrastructure of the physical space provides special tables, chairs and equipment storage to allow easy access and sharing of technology with all students. Students sit with team members to engage in collaborative problem solving activities during class. In the Classroom Studio, each team of four has two computers to work with and in the Design Studio, every student has access to a Tablet PC to support their inquiry into the many innovative learning activities the instructional team has prepared for the class session. Also, a fast network of both wired and wireless capabilities opens a host of methods for students to access information, develop computational models for analysis, interact with online simulations and eventually gather data through experiments using sensors and analog-to-digital boxes connected to classroom computers. In addition, advancing classroom assessment software (e.g. Classroom Presenter™, DyKnow™, and others) allow interesting new methods for instructors to engage their class in discussions that encourage students to make their thinking explicit and then share it with the class. Through this sharing, the instructor can monitor students' conceptual understanding of the course content and make adjustments based on student's needs.

Each year the First-Year Engineering program leads over 1700 students into the world of engineering through these two studios. Currently we are using programmable Lego® kits as a mechanism to engage students in similar design activities that become shared experiences by all students. Instruction is easier when an instructor knows all the students have the same prior knowledge, that is, the experiences of trying to solve a problem or project with the Lego® tools. With revisiting of similar content through various projects with the Lego®'s, students will begin to see the important, but subtle, differences of the content knowledge relative to the various conditions they engaged in during the project.

The others studios are smaller and support the students who are most interested in pursuing disciplines related to the use of this equipment. These studios provide teams of students multiple opportunities to construct and test their physical prototypes of their designs. Prior to conducting their actual physical prototypes, students have access to a number of commercially available software packages for drawing 3D renderings of their ideas. These and other modeling tools help students analyze the appropriateness of their design decisions and make modifications to their ideas prior to actually building anything.

The combination of the physical and technological infrastructure of our studios and advanced pedagogical methods should lead to all our students developing the attributes of Purdue's Engineer of 2020. The technology engages student in activities that give meaning to the future work they will be doing and provides important formative assessment data for instructors to monitor students' performance to the course objectives.

6. PROGRAM ASSESSMENT

Assessment to date includes an analysis of grade distributions, attendance records, and student attitudinal and satisfaction questionnaires. Future assessment will include retention to the second year, persistence in engineering and the university, and performance in follow-on courses. The grade distributions have changed dramatically in the general introductory course. One reason could be correlated with the change in attendance. This might be explained by the decrease in class size making students far less anonymous or the constant dependency on the team structure where students were held accountable for the absence of their teammates. Reported below are indicators of how this new learning environment changed student perceptions of their own learning, teaming, attainment of course learning objectives, and the use of engagement activities for learning.

Table 2. Grade Distribution Comparison for Fall

	F07	F07%	F08	F08%
A	439	25%	482	42%
B	919	51%	534	46%
C	255	14%	82	7%
D	43	2%	13	1%
F	53	3%	18	2%
W	81	5%	32	3%

Grade Distributions: Grade distributions are just one indicator of possible retention improvement. There are many factors that go into grade distributions that are noted, such as abilities of the incoming student population, change in instructor, etc. With that note, the DFW rate or students who earn a grade of a D or F in the class and those who choose to withdraw summed together is an important indicator of retention. For the fall of 2008, this rate was reduced from the previous fall 2007 rate of 10% to a rate of 5.5%.

Attendance: Attendance comparisons were made in a subset of the courses taught by one professor. This analysis accounts for approximately 30% of the fall student population in both 2007 and 2008 and 100% of the spring student population in 2007 with only 30% again in spring 2008. It is important to note that the spring student population is significantly different than the fall. As the course has been taught, the spring semester is an 'off' semester, and approximately one-third of students enrolled in the spring semester were retaking the class, one third were transfer students, and about one-third were from other admission colleges outside of engineering.

In the fall of 2007, attendance was collected in one section of the four being taught. The enrollment was 462 in this section. Each percentage is calculated as the number responding to (but not necessarily getting right) at least one question in class using eInstruction Classroom Performance System (CPS) response pads ('clickers'). Students were informed that their responses were being used to keep track of attendance and they were informed that attendance was 5% of their grade. As reflected in Table 3, the overall attendance for the dates collected is 80%.

In the fall of 2008, attendance was collected in three of the ten sections taught and all three were taught by the same professor and the same professor as the fall 2007 data. The enrollment was 120 in each section for a total enrollment of 360. Students were aware that TAs kept track of attendance using a roster/checklist and they were informed that attendance was 5% of their grade. In this semester, TAs checked if absent students had let their teammates know ahead of time. As reflected in Table 3, the overall attendance for the dates collected is 97%. Statistical analysis of the fall 2007 vs. fall 2008 attendance using a t-Test: Two-Sample Assuming Unequal Variances, two-tailed

Table 3. Attendance Comparisons for Fall

Fall 2007		Fall 2008				
Date	Attendance	Week of	Tuesday 11:30–1:30	Tuesday 1:30–3:30	Thursday 3:30–5:30	Avg. weekly Attendance
30-Aug	89%					
4-Sep	86%					
11-Sep	86%	22-Sep	98%	96%	99%	98%
13-Sep	79%	29-Sep	100%	100%	98%	99%
20-Sep	83%	6-Oct	98%	96%	98%	97%
25-Sep	86%	13-Oct	NA	NA	98%	98%
4-Oct	68%	20-Oct	98%	98%	96%	98%
18-Oct	79%	27-Oct	94%	95%	97%	95%
23-Oct	76%	3-Nov	91%	98%	98%	96%
6-Nov	79%	10-Nov	NA	97%	95%	96%
15-Nov	71%	17-Nov	95%	99%	96%	97%
Fall 07 Overall	**80%**				**Fall 08 Overall**	**97%**

resulted in a p-value < 0.0001, indicating a significant increase in attendance.

Fall 2007 should be considered conservative in that use of CPS response pads for collecting attendance data was subject to manipulation by students, who would sometimes register responses with another students' response pads, even though students were informed that this practice was a violation of academic integrity. While we are optimistic that improvements in engagement are at least partly responsible for the dramatic improvement in attendance, other changes in that period could also have affected the attendance rate. The 2008 practice of taking attendance on a personal basis increases accountability, as does the practice of asking the remaining team members if they were aware of the whereabouts of missing team members. It is believed that the increased visibility of students in a smaller class size (which is itself related to engagement) contributed to accountability as well. Finally, the reconfiguration of the course to be taught in two 2-hour blocks (rather than two 1-hour blocks and a two-hour lab) increases the significance of missing a class meeting.

In spring of 2007, attendance was collected in the both of the sections taught that semester. The total enrollment was 369. Each percentage is calculated as the number responding to (but not necessarily getting right) at least one question in class using eInstruction Classroom Performance System (CPS) response pads ('clickers'). Students were informed that their responses were being used to keep track of attendance and they were informed that attendance was 5% of their grade. As reflected in Table 4, the overall attendance for the dates collected is 67%.

In spring of 2008, attendance was collected in one of three sections taught again by the same professor as the spring of 2007 data. The section enrollment was 120. Students were aware that TAs kept track of attendance using a roster/checklist and they were informed that attendance was 5% of their grade. In this semester, TAs checked if absent students had let their teammates know ahead of time. Although a surprising number of students were engaging in this professional behavior, absences of which teammates were informed in advance were still counted as absences. As reflected in Table 4, the overall attendance for the dates collected is 76%. Statistical analysis of the spring 2007 vs. spring 2008 attendance using a t-Test: Two-Sample Assuming Unequal Variances, two-tailed resulted in a p-value < 0.0001, indicating a significant increase in attendance.

Attitudinal Surveys: Each semester, first-year students are asked to complete several instruments that look at the affective domain of learning. These surveys cover such topics as life long (or more recently donned continuous) learning, course elements, methods of success, and teaming. In addition, questions related to the learning environment were added to understand the impact of the new space. The analysis of these data is divided into Honors and non-Honors due to the different average demographics of each of these student populations. Honors within the College of Engineering is a choice provided to students who have

Table 4. Attendance Comparisons for Spring

Spring 2007		Spring 2008	
Date	Attendance	Date	Attendance
		17-Jan-08	76%
23-Jan-07	71%	24-Jan-08	83%
25-Jan-07	66%	29-Jan-08	80%
30-Jan-07	72%	31-Jan-08	72%
1-Feb-07	65%	5-Feb-08	74%
6-Feb-07	69%	7-Feb-08	85%
8-Feb-07	69%	12-Feb-08	77%
15-Feb-07	67%	14-Feb-08	79%
20-Feb-07	73%	19-Feb-08	81%
22-Feb-07	68%	21-Feb-08	58%
27-Feb-07	69%	26-Feb-08	81%
1-Mar-07	69%	28-Feb-08	76%
6-Mar-07	65%	6-Mar-08	61%
20-Mar-07	64%	18-Mar-08	78%
27-Mar-07	61%	27-Mar-08	75%
5-Apr-07	56%	3-Apr-08	75%
Spr 07 Overall	**67%**	**Spr 08 Overall**	**76%**

Table 5. Lifelong Learning

Lifelong Learning	Group A			Group B		
Deep learning and Surface learning: Items per Study Process Questionnaire (SPQ) [50].	Fall 07	Fall 08	p-value*	Fall 07	Fall 08	p-value*
Deep learning—Mean sum score of 10 Items (10 low, 50 high).	32.85	33.13	0.1675	33.47	32.25	0.006
Surface Learning—Sum score of 8 items (8 low, 40 high).	22.66	22.71	<0.0001	19.50	20.81	0.0001

Group A—Fall 07, n = 529 from Non-Honors student population.
Group A—Fall 08, n = 877 from Non-Honors student population.
Group B—Fall 07, n = 203 from Honors student population.
Group B—Fall 08, n = 220 from Honors student population.
* Per Mann-Whitney.

high initial SAT/ACT and High School GPA and later by petition. In the following tables, non-Honors are included as Group A and Honors are included as Group B.

Table 5 presents results for the students' perception of their deep and surface learning characteristics as per Biggs, Kember and Leung [52] at the end of their first semester. Most notable is the fact that mean values for both deep and surface learning went up for Group A from fall 07 to fall 08 (with the shift in surface learning being significant). An increase in the mean value of the deep learning scale would indicate an increase in deep learning characteristics, something faculty would traditionally value. At the same time, an increase in the surface learning mean score would suggest students believe their academic success is attributable to more surface-like learning characteristics (something faculty believe would not be conducive to deep conceptual understanding). On the other hand Group B results for the fall 07 and fall 08 cohorts indicate that both the deep learning mean shifted down and the surface learning mean shifted up (both significant). This shift is contrary to that which was expected and warrants more investigation.

When looking at core aspects of the course (Table 6), Group A and B students had different experiences. When going from a very large section size (450) to smaller section sizes (120), Group A students tended to report that core aspects of the course (e.g., lecture, labs, projects, and being a member of a team) were executed better from fall 07 to fall 08. However, Group B students (who were taught in a section of 220 and are now taught in sections of 60) reported lower mean scores from fall 07 to fall 08 across all items. It is believed that Honors students, while adaptable in many ways, are more resistant to a change in their educational paradigm (from lecture to discussions and labs to activities) that have been very successful for them in the past.

Table 7 presents attitudinal data on students' belief of what it takes to be successful in the new course format. Not surprising, Group A students believed that taking ownership, learning a new language (i.e., the language of engineering), being an active participant in class, coming to class prepared, learning to be accountable, and relying on one's peers was more true in a smaller class (fall 08, 120 students) than in large lecture sections. However, for the Honors students (Group B) the downward mean shift from fall 07 to fall 08 was

Table 6. Course Elements

Course Elements	Group A			Group B		
Mean score of 5 point Likert Scale (Poorly (1)—Very Well (5))	Fall 07	Fall 08	p-value*	Fall 07	Fall 08	p-value*
The purpose of the lecture is to introduce and explain the theory behind the course material and relate the material to engineering applications.	3.17	3.79	<0.0001	3.24	2.76	<0.0001
The purpose of the laboratory is to provide you with 'hands-on' exposure to the course material and allow you the opportunity to experiment with the computer system and the various software packages.	3.73	3.96	<0.0001	4.13	3.18	<0.0001
Team Projects are designed to provide you with an opportunity to apply your newly acquired problem solving and computer skills to the solution of engineering problems.	3.37	3.73	<0.0001	3.68	3.18	<0.0001
The purpose of teaming is to help you learn to become an effective member of a technical team.	3.66	4.02	<0.0001	4.17	3.61	<0.0001

Group A—Fall 07, n = 529 from Non-Honors student population.
Group A—Fall 08, n = 877 from Non-Honors student population.
Group B—Fall 07, n = 203 from Honors student population.
Group B—Fall 08, n = 220 from Honors student population.
* Per Mann-Whitney.

Table 7. Student Requirements for Success in Course

Success in this course requires one to:	Group A			Group B		
Mean score of 5 point Likert Scale (Does not Apply (1)—Very True (5))	Fall 07	Fall 08	p-value*	Fall 07	Fall 08	p-value*
Take ownership of your education and learning process. Successful problem solvers must practice and learn materials on their own.	4.07	4.21	0.0037	4.33	4.15	0.0589
Remember that you are beginning to learn a new language—the language of engineering. Most freshman engineering students do not have a background in engineering. When problems are placed in an engineering context that uses the language of engineering, as will occur in ENGR, you may find some problems difficult to understand at first glance.	4.01	4.12	0.0241	4.15	3.85	0.0009
Be an active participant in classroom activities. The more engaged you are in the classroom, the more you will get out of class.	3.84	4.06	<0.0001	3.98	3.62	0.0001
Come prepared for class. By doing the reading assignments before class, you will understand more of the content covered in class.	3.88	4.07	0.0003	4.04	3.79	0.0046
Learn to be accountable to your team and have your team be accountable to you to complete assignments and learn course material. You will be working in a team of four (or three) in lab, lecture, and on projects. You will need to be an active participant on the team.	4.18	4.36	0.0001	4.63	4.28	<0.0001
Rely on your peers as well as the faculty and staff to learn the course material. Your peers are a great resource. On the flip side, your peers may come to you for help. By helping your peers learn the material, you will gain greater understanding of the course material. Do not be reluctant to contact any member of the ENGR Instructional Team when you need help. All faculty have regularly schedule office hours, and there are evening office hours staffed by the teaching assistants.	4.04	4.20	0.0006	4.39	3.99	<0.0001
Be aware that you will solve problems for which there are no unique solutions. Due to this fact you may get many different responses when you seek help on a problem because there are many different ways to solve the problem.	4.10	4.32	0.000	4.37	4.00	<0.0001

Group A—Fall 07, n=529 from Non-Honors student population.
Group A—Fall 08, n=877 from Non-Honors student population.
Group B—Fall 07, n=203 from Honors student population.
Group B—Fall 08, n = 220 from Honors student population.
* Per Mann-Whitney.

not expected. As stated previously, one could expect that Honors students are more resistant to a change in their educational paradigm (from lecture to discussions and labs to activities) that has been very successful for them in the past. The results indicate that faculty teaching the new course will need to take more time introducing the rationale for the new course format.

Tables 8 and 9 present results about the learning environment and course format. From a facilities perspective, students overwhelmingly reported that both the classroom studio and design studio were more conducive to and better equipped to support student learning (both as individuals as well as in a team). In terms of the class format (for Group B), the students generally agreed that the use of 'discussions' (versus lectures), 'activities' (versus labs), and the use of studio contact hours (extended structured time in class) was more engaging and help them learn course content better, which is interesting given the results presented in Tables 5–7.

Table 8. Facilities Attributes

Comparing I2I Facilities to other classes with 100 or more students: 5 point Likert Scale (Disagree (1)—Strongly Agree (5)	Strongly Disagree & Disagree	Neutral	Agree & Strongly Agree
The Classroom Studio—13 items described various classroom attributes. Average results are presented (a response of 5 indicates an improved learning environment).	2.56%	13.98%	83.46%
The Design Studio—13 items described various classroom attributes. Average results are presented (a response of 5 indicates an improved learning environment).	2.37%	14.07%	83.57%

Combined Fall 08, n = 596 from Non-Honors student population and Fall 08, n = 220 from Honors student population.

Table 9. Course Delivery Format

Course Format: 5 point Likert Scale (Strongly Disagree (1)—Strongly Agree (5)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I liked how the course was organized with 'discussion' and 'activity' times.	12.96%	22.69%	30.56%	31.48%	2.31%
I felt more prepared for my homework after participating in the activities we did in this course compared to a 'traditional' lecture class.	1.85%	8.64%	30.09%	56.17%	3.24%
I made effective use of my time in this class for learning course material.	7.91%	14.87%	34.11%	36.15%	6.96%
The 'discussion' and 'activity' format of this class gave me a better opportunity to explore concepts in more depth compared to a 'traditional' lecture class.	4.76%	11.31%	38.10%	41.22%	4.61%
The 'discussion' and 'activity' format of this class gave me a better opportunity to understand how course materials are inter-related compared to a 'traditional' lecture class.	2.88%	7.88%	30.00%	53.94%	5.30%
My understanding of course concepts was improved through a combination of 'hands on exercises' and 'discussions.'	3.07%	24.72%	46.65%	20.39%	5.17%

Fall 08, n = 220 from Honors student population

7. CONCLUSIONS

The First-Year Program at Purdue University is one of the largest programs in the nation in that typical first-year enrollment exceeds 1700 students annually [53]. As such, the program has historically taught very large lecture courses with their associated recitation or lab sections to try to achieve the individual learning needed by students. Through the opportunity of designing dedicated learning space and utilizing established research in the areas of learning spaces, engaged learning, and learning technologies, a first-year experience has been transformed based on the results of years of research. Stephen Bechtel, Sr. might have said it best with the following quote;

> Size can work to your advantage if you think big. —
> *Stephen Bechtel, Sr.*

The move to a new facility filled with state of the art learning technologies and a change of course content and structure has resulted in a significantly different grade distribution where more students are passing the course with higher rates of attendance. In addition, attitudinal data shows positive increases for the non-Honors students while the Honors students do not indicate the same trend. Though more research is needed on several aspects of this facility, the curricular change, and metrics such as retention, persistence, and follow-on course success, applying the research in the creation of a facility and its associated pedagogy and curriculum has allowed for a positive transition for a large number of aspiring engineers.

REFERENCES

1. National Science Foundation, *America's Academic Future*, A Report of the Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond, Directorate for Education and Human Resources, NSF, January, 1992.
2. T. Andre, Minds-on and Hands-on Activity: Improving instruction in Science for All Students, *Mid-Western Educational Researcher*, **10**(2), 1997, p. 28.
3. S. J. Derry, Cognitive Schema Theory in the Constructivist Debate, *Educational Psychologist*, **31**(3/4), 1995, p. 163.
4. E. L. Ferguson and M. Hegarty, Learning with Real Machines or Diagrams: Application of Knowledge to Real-World Problems, *Cognition and Instruction*, **13**(1), 1995, p. 129.
5. L. E. Carlson and J. F. Sullivan, Hands-on Engineering: Learning by Doing in the Integrated Teaching and Learning Program, *International Journal of Engineering Education*, **15**(1), 1999, p. 20.
6. T. L. Schwartz and B. M. Dunkin, Facilitating Interdisciplinary Hands-on Learning using LabView, *International Journal of Engineering Education*, **16**(3), 2000, p. 218.
7. D. W. Kirmse, The Computer-Aided Process Improvement Laboratory, *The Innovator*, published by the NSF SUCCEED Coalition, 1994, p. 12.
8. D. Gillet, et al., Introduction to Automatic Control via an Integrated Instruction Approach, *3rd IFAC Symposium on Advances in Control Education*, IFAC, 1994, p. 83.
9. D. Gillet, et al., Telepresence: An Opportunity to Develop Practical Experimentation in Automatic Control Education, *European Control Conference*, Brussels, Belgium, 1997.
10. D. Gillet, Hands-On laboratory Experiments in Flexible and Distance Learning, *Journal of Engineering Education*, **90**(2), 2001, p. 187.
11. B. A. Foss, T. I. Eikaas and M. Hovd, Merging Physical Experiments Back into the Learning Arena, *19th American Control Conference*, Chicago, IL, 2000.

12. M. Ohland, E. Stephan and B. Sill, Clemson University's EXPerimental Engineering in Real Time (EXPERT) Program: Assessing the benefit of real-time sensors in the curriculum, *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition*, June 2003.
13. Accreditation Board of Engineering and Technology, http://abet.org, accessed 5/24/09.
14. National Academies Press, *The Engineer of 2020: Visions of Engineering New Century*, 2004.
15. G. Wiggins and J. McTighe, Understanding by Design, Merrill Education/ASCD College Textbook Series, ASCD, Alexandria, Virginia, 1998.
16. J. D. Bransford, A. L. Brown and R. R. Cocking, *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academy Press, 1999.
17. R. J. Beichner, J. M. Saul, R. J. Allain, D. L. Deardorff, D. S. Abbott, *Introduction to SCALE UP: Student-Centered Activities for Large Enrollment University Physics*, Proceedings 2000 American Society for Engineering Education National Conference.
18. R. M. Felder and R. Brent, *Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs*, Report to the National Science Foundation, ERIC Document Reproduction Service No. ED 377 038, 1994.
19. R. R. Hake, Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanical test data for introductory physics courses, *Am. J. Phys*., **66**, 1998, pp. 64–64.
20. E. Mazur, *Peer Instruction*, Prentice Hall, New Jersey, 1997.
21. R. M. Felder, G. N. Felder and E. J. Dietz, A Longitudinal Study of Engineering Student Performance and Retention. V: Comparisons with Traditionally Taught Students, *Journal of Engineering Education,* **87**(4), 1998, pp. 469–480.
22. R. J. Beichner, J. M. Saul, R. J. Allain, D. L. Deardorff and D. S. Abbott, *Promoting collaborative groups in large enrollment courses*, Proceedings of the 2000 Annual meeting of the American Society for Engineering Education.
23. H. A. Diefes-Dux, T. Moore, J. Zawojewski, P. K. Imbrie and D. Follman, *A Framework for Posing Open-Ended Engineering Problems: Model Eliciting Activities*, Proceedings of the 2004 Frontiers in Education Conference, Savannah, Georgia, 2004.
24. J. D. Bransford, S. Brophy and S. Williams, When Computer Technologies Meet the Learning Sciences: Issues and Opportunities, in: *Journal of Applied Developmental Psychology*, **21**(1), 2000, pp. 59–84; King A., Transactive Peer Tutoring: Distributing Cognition and Metacognition, in: *Educational Psychology Review*, **10**, 1998, pp. 57–74.
25. R. Glaser and M. Bassok, Learning Theory and the Study of Instruction, *Annual Review of Psychology*, 1989, **40**(1), pp. 631–666.
26. C. J. Atman, and J. Turns, *Relating Findings from the Learning Sciences to Engineering Education*, CELT Technical Report CELT-01–06, 2001.
27. K. A. Smith, *Cooperative Learning: Effective Teamwork for Engineering Classrooms*, 1995, Frontiers In: Education Conference Proceedings, Atlanta, GA.
28. D. W. Johnson, R. Johnson, and K. Smith, *Active Learning: Cooperation in the College Classroom*. Edina, MN: Interaction Book Company, 1998.
29. National Science Foundation Directorate for Education and Human Resources, *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology*. www.nsf.gov/pubs/stis1996/nsf96139/nsf96139.txt, 1996.
30. National Research Council, *Transforming Undergraduate Education in Science, Mathematics, Engineering and Technology*. National Academies Press. Washington, D.C., 1999.
31. R. M. Felder, D. R. Woods, J. E. Stice and A. Rugarcia, The Future of Engineering Education: Teaching Methods that Work, *Chemical Engineering Education,* **34**(1), pp. 26–39.
32. J. D. Bransford and D. L. Schwartz, Rethinking Transfer: A Simple Proposal With Multiple Implications, In: Iran-Nejad, A. and Pearson, P. D. (eds.), *Review of Research in Education.* **24**, pp. 61–100. American Educational Research Association (AERA): Washington, DC.
33. L. C. McDermott, Millikan Lecture 1990: What we teach and what is learned—Closing the gap, *American Journal of Physics* **59**, 1991, p. 301.
34. P. Laws, Calculus-based physics without lectures, *Phys. Today* **44**(12), 1991, pp. 24–31.
35. D. Hestenes, M. Wells and G. Swackhammer, Force Concept Inventory, *The Physics Teacher* **30**, 1992, pp. 141–151.
36. R. M. Felder, K. D. Forrest, L. Baker-Ward, E. J. Dietz and P. H. Mohr, A Longitudinal Study of Engineering Student Performance and Retention. I. Success and Failure in the Introductory Course, *Journal of Engineering Education*, **82**(1), 1993, pp. 15–21.
37. R. M. Felder, P. H. Mohr, E. J. Dietz and L. Baker-Ward, A Longitudinal Study of Engineering Student Performance and Retention. II. Differences Between Students from Rural and Urban Backgrounds, *Journal of Engineering Education*, **83**(3), 1994, pp. 209–217.
38. R. M. Felder, G. N. Felder, M. Mauney, C. E. Hamrin, Jr. and E. J. Dietz, A Longitudinal Study of Engineering Student Performance and Retention. III. Gender Differences in Student Performance and Attitudes, *Journal of Engineering Education*, **84**(2), 1995, pp. 151–174.
39. R. M. Felder, A Longitudinal Study of Engineering Student Performance and Retention. IV. Instructional Methods and Student Responses to Them, *Journal of Engineering Education*, **84**(4), 1995, pp. 361–367.
40. R. J. Beichner and J. S. Risley, SCALE-UP (Student Centered Activities for Large Enrollment University Physics), https://www.fastlane.nsf.gov/servlet/showaward?award=9752313, 1997.
41. R. J. Beichner and J. S. Risley, SCALE-UP (Student Centered Activities for Large Enrollment University Physics), https://www.fastlane.nsf.gov/servlet/showaward?award=9981107, 1999.
42. R. J. Beichner, L. Bernold, E. Burniston, P. Dail, R. Felder, J. Gastineau, M. Gjertson and J. Risley, Case study of the physics component of an integrated curriculum, *Physics Education Research Supplement to American Journal of Physics* **67**(7), 1999, S16, 1999.
43. J. M. Saul, D. L. Deardorff, D. S. Abbott, R. J. Allain and R. J. Beichner, *Evaluating introductory physics classes in light of ABET criteria: An Example of SCALE-UP Project*, Proceedings of the 2000 Annual meeting of the American Society for Engineering Education.

44. E. F. Redish and R. Steinberg, Teaching physics: Figuring out what works, *Physics Today* **52**, January 24, 1999.
45. National Academy of Engineering (NAE), Changing the Conversation: Messages for Improving Public Understanding of Engineering, 2008.
46. National Academy of Engineering, 'Grand Challenges for Engineering', accessed 1-9-09, http://www.engineeringchallenges.org/, 2009.
47. T. Moore, H. Diefes-Dux, and P. K. Imbrie, *Developing First-Year Students, Perceptions of the Engineering Profession Through Realistic Client-Driven Problems*, Proceedings of the 2005 Frontiers in Education Conference, Indianapolis, Indiana, 2005.
48. T. Moore, H. Diefes-Dux and P. K. Imbrie, *The Quality of Solutions to Open-Ended Problem Solving Activities and its Relation to First-Year Student Team Effectiveness*, Proceedings of the 2006 American Society of Engineering Education Annual Conference and Exposition, Chicago, Illinois, 2006.
49. R. E. Stamper and D. L. Dekker, *Utilizing Rapid Prototyping To Enhance Undergraduate Engineering Education*, Proceedings of the 2000 Frontiers in Education Conference, Kansas City, Missouri.
50. I. Fidan, *Work in Progress: Onground versus Distance Rapid Prototyping Practices*, Proceedings of the 2000 Frontiers in Education Conference, Saratoga Spring, New York.
51. R. E. Barr, P. S. Schmidt, T. J. Krueger and C. Twu, An Introduction to Engineering Through an Integrated Reverse Engineering and Design Graphics Project,' *Journal of Engineering Education*, **89**(4), 2000, pp. 413–418.
52. J. Biggs, D. Kember and D. Leung, The Revised Two-Factor Study Process Questionnaire: R-SPQ-2F, *British Journal of Educational Psychology*, **71,** pp. 133–149.
53. American Society for Engineering Education, *Engineering Profiles and Statistics*, 2007 edition, published June, 2008.

Teri Reed-Rhoads is assistant dean of engineering for undergraduate education, associate professor of Engineering Education, and director of the First-Year Engineering Program at Purdue University. She holds a B.S. in petroleum engineering from the University of Oklahoma, an M.B.A., and a Ph.D. in industrial engineering from Arizona State University. With industry and academic experience, she has received funding from NSF, DoEd, foundations, and industry for research addressing concept inventory development, assessment and evaluation, recruitment/retention topics, leadership, diversity, and equity. She is a Fellow of ASEE and serves as an ABET EAC evaluator. She is also a member of IEEE and IIE.

P. K. Imbrie is an Associate Professor of Engineering in the School of Engineering Education at Purdue University. He holds B.S., M.S. and Ph.D. degrees in Aerospace Engineering from Texas A&M University. His current research interests include: epistemological development, modeling, and assessment of student learning, student success, student team effectiveness, and global competencies; experimental mechanics; piezospectroscopic techniques; microstructural evaluation of materials; and experiment and instrument design. He has been involved with various research projects sponsored by NSF, NASA, and AFOSR, ranging from education related issues to traditional research topics in Aerospace Engineering. He is an active member of ASEE.

Kamyar Haghighi is the founding head of the School of Engineering Education at Purdue University. His areas of interest are engineering curriculum reform; outcome-based assessment of student's learning; and leadership and policy. He led the development of the vision and the creation of the first department of engineering education and the first graduate degree program in engineering education in the world. Dr. Haghighi was a driving force behind the Engineering Education Research Colloquies which resulted in the development and publication of a research agenda for research in engineering education. He also serves on the ASEE Journal of Engineering Education Advisory Board.

David F. Radcliffe is the Epistemology Professor of Engineering Education and the current Kamyar Haghighi Head of the School of Engineering Education at Purdue University with interests in engineering design research, empirical studies of engineering practice, learning space design and knowledge networks. He is a Past President of the Australasian Association of Engineering Education. David received a BE and MEngSc in mechanical engineering from University of Queensland and a PhD in bioengineering from Strathclyde.

Sean Brophy is an Assistant Professor of Engineering Education at Purdue University. He has a Ph.D. in Education and Human Development from Vanderbilt University, a M.S. in Computer Science from DePaul University, and a B.S. in Mechanical Engineering from the University of Michigan. He holds a patent in the area of multiple fluid speed systems. His research interests include reasoning with mathematics and models, technology supported learning environments, conceptual change, and designing assessment for learning. He is a member of AERA, IEEE, and ASEE. He won the Development of Instructional Design Association Outstanding Article of the Year award in 2000.

Matthew W. Ohland is Associate Professor of Engineering Education at Purdue University. He has degrees from Swarthmore College, Rensselaer Polytechnic Institute, and the University of Florida. His research on the longitudinal study of engineering students, team assignment, peer evaluation, and active and collaborative teaching methods has been supported by over $11.4 million from the National Science Foundation and the Sloan Foundation and his team received the William Elgin Wickenden Award for the Best Paper in the Journal of Engineering Education in 2008 and multiple conference Best Paper awards. Dr. Ohland is Chair of ASEE's Educational Research and Methods division and an At-Large member the Administrative Committee of the IEEE Education Society. He was the 2002–2006 President of Tau Beta Pi.

Eric Holloway received a B.S.E.E. from Purdue University and is the Director of Instructional Laboratories in the School of Engineering Education at Purdue University. He has over 15 years of industrial experience, specializing in electronic controls, for which he holds 4 patents. Since working at Purdue, he was in charge of the implementation of the Ideas to Innovation Learning Laboratory. He has worked at Toyota, Cummins, Woodward, and TRW. He is currently one of two university representatives on the Haas Technical Education Council.