Estimates of Use of Research-Based Instructional Strategies in Core Electrical or Computer Engineering Courses

Jeffrey E. Froyd, Fellow, IEEE, Maura Borrego, Stephanie Cutler, Charles Henderson, and Michael J. Prince

Abstract—Many research-based instruction strategies (RBISs) have been developed; their superior efficacy with respect to student learning has been demonstrated in many studies. Collecting and interpreting evidence about: 1) the extent to which electrical and computer engineering (ECE) faculty members are using RBISs in core, required engineering science courses, and 2) concerns that they express about using them, are important aspects of understanding how engineering education is evolving. The authors surveyed ECE faculty members, asking about their awareness and use of selected RBISs. The survey also asked what concerns ECE faculty members had about using RBISs. Respondent data showed that awareness of RBISs was very high, but estimates of use of RBISs, based on survey data, varied from 10% to 70%, depending on characteristics of the strategy. The most significant concern was the amount of class time that using an RBIS might take; efforts to increase use of RBISs must address this.

Index Terms—Change in engineering education, diffusion of innovations, faculty adoption, faculty awareness, research-based instructional strategies (RBISs), teaching.

I. INTRODUCTION

RESEARCHERS have applied research on learning to create multiple instructional strategies that have demonstrated their efficacy with respect to student learning, particularly in the disciplines of engineering, science, and mathematics [1]–[3]. These strategies, which will be referred to collectively in this paper as research-based instructional strategies (RBISs) [4], include learning in small groups [5], active learning [6], cooperative learning [7], [8], service learning [9], [10], peer-led team learning [11], peer instruction [12], just-in-time teaching [13], and inductive teaching approaches [14] such as problem-based learning, project-based learning, inquiry-based learning, and challenge-based learning.

These and other instructional strategies have been advocated in recent reports from the American Society for Engineering Education (ASEE) [15], [16]. Although RBISs have been developed, implemented, and studied extensively, the extent to which faculty members in engineering, science, and mathematics have applied these strategies has been questioned. Reports suggest that lecture remains the predominant strategy by large margins [17]–[19], and that cultural norms supporting interactive strategies are lacking [20]. Understanding the extent to which these strategies are adopted (or not) by electrical and computer engineering (ECE) faculty members, as well as examining how to promote these instructional approaches, may lead to greater understanding of the influences that enhance or reduce likelihood of adoption of RBISs [21], [22]. This paper reports on one step in this research process, specifically asking the following.

1) What are levels of awareness and use of RBISs for individual ECE faculty members teaching circuits, electronics, and introductory digital logic or digital design?
2) What barriers to broader adoption of individual RBISs do ECE faculty members report?

The authors focused on ECE faculty members teaching selected core, required courses, usually at the sophomore level. These courses were chosen as the focus for the study because educational practices in core engineering science courses have remained, by and large, unchanged [23], [24].

II. LITERATURE REVIEW

Several theories can be used in studying change in undergraduate engineering education. Diffusion of innovations [25] predicts relationships between different awareness and adoption levels and characteristics of innovations, the potential adopters, the change agents, and their networks. It also includes predictions for change over time, including the stages that potential adopters move through in deciding whether to implement and continue with an innovation, and how an innovation reaches a “tipping point” of widespread use. It is applied here because a develop-then-disseminate model is the preferred approach of many science, technology, engineering, and mathematics (STEM) faculty members, including those who originally developed the RBISs under study [26], [27].

1In the literature on diffusion of innovations, the focus is on many different types of innovations. This literature review will use the term “innovations” since that is frequently used in the field. However, for the study described in this paper, innovations being studied are RBISs, and in the rest of the paper, the authors use “RBISs” to refer to the innovations being studied.

Manuscript received September 21, 2012; accepted November 26, 2012. Date of publication February 20, 2013; date of current version October 28, 2013. This work was supported by the U.S. National Science Foundation under Grants 1037671 and 1037724.

J. E. Froyd is with Engineering Student Services and Academic Programs, Texas A&M University, College Station, TX 77843-3127 USA (e-mail: froyd@tamu.edu).

M. Borrego and S. Cutler are with the Department of Engineering Education, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061 USA.

C. Henderson is with the Department of Physics, Western Michigan University, Kalamazoo, MI 49008 USA.

M. J. Prince is with the Department of Chemical Engineering, Bucknell University, Lewisburg, PA 17837 USA.

Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

Digital Object Identifier 10.1109/TE.2013.2244602
Adoption of innovations by a population follows an S-shaped curve. A sample adoption S-curve is depicted in Fig. 1(a). At first, the plot of cumulative users over time is very flat, as just a few innovators learn about and adopt the innovation. As more centrally involved people become users and their approval is noted by others, the curve arches upward as the innovation is adopted by the majority. In the end, only a few late adopters are left, and the curve is again flat. However, broad adoption [e.g., in Fig. 1(a), 100% adoption] is not the norm. Alternative scenarios such as Fig. 1(b) are more common, in which the innovation does not diffuse broadly through the system. In terms of engineering education, this is what happens when few faculty members discover a classroom practice, and some of them abandon it after a trial period.

Rogers suggests that once a cumulative adoption of 40%–50% is achieved, then the innovation will eventually reach saturation in terms of adoption. Although this is an overly simplified model of adoption, it provides a useful lens for viewing adoption of each RBIS. For example, although readers intuitively know that RBISs with higher rates of adoption are more likely to persist, this theory gives credence to the interpretation that those RBISs above 50% adoption may have already reached their tipping point and are more likely to eventually reach full or nearly full adoption. On the other hand, those RBISs with particularly low adoption levels either are not mature enough or will never achieve full adoption.

The following criteria were used to identify RBISs examined in this study:
1) documented use in engineering settings at more than one institution;
2) demonstrated positive influence on student learning in engineering or STEM.

Applying these criteria led to the selection of 12 RBISs. Brief descriptions, references, and evidence for efficacy of the RBISs were provided in a previous paper [28].

III. METHODOLOGY

A national survey investigating faculty use of RBISs was completed in Spring 2011; the survey population was ECE faculty members who had recently taught a sophomore-level engineering science course (circuits, electronics, or introductory digital logic and/or digital design).

A. Instrument

The survey instrument was adapted from a previous survey of introductory physics instructors [21], [29] and was divided into three main sections. The first section asked faculty about the amount of class time spent on different activities generally associated with RBIS use. Responses to this section are not discussed in this paper. The second asked faculty members to self-report their level of knowledge and/or use of each RBIS. For each RBIS that was described in the survey, participants were given the following options: 1) I currently use it; 2) I have used it in the past; 3) I have used something like it but did not know the name; 4) I am familiar with it, but have never used it; and 5) I have never heard of it. The order was not randomized, and this design decision was acknowledged in the limitations. The third section collected demographic information such as gender, rank, and how often respondents attend talks or workshops about teaching.

B. Survey Population

The population for this survey is all faculty members in US ABET-accredited electrical and computer engineering programs who had taught sophomore-level circuits, electronics, or introductory digital logic and/or digital design in the two years prior to survey administration.

The research team compiled a list of all the ABET-accredited electrical and computer engineering programs in the US; the Virginia Tech Center for Survey Research (CSR) then contacted each department listed to identify the instructors for each of the courses of interest.

C. Survey Administration

In Spring 2011, each potential respondent received an e-mail invitation containing a survey link and up to three weekly reminders. To encourage responses, the e-mail was endorsed and signed by the then-president of the IEEE Education Society. Also, gift cards to retail stores were raffled off as survey incentives. There were 130 electrical and computer engineering early responses out of 923 contacted faculty members. Of those responses, those who were not teaching the classes of interest or did not complete a majority of the items were not included in the analysis, leaving 115 electrical and computer engineers who completed the survey. The response rate was thus 12.4%. To estimate potential response bias, a second round of data collection was conducted in Fall 2011. Initial nonrespondents (N = 25) were contacted by Center for Survey Research staff and encouraged to complete the survey. Ten additional responses were obtained; of those, there were seven usable responses. There were no significant differences between the early and late respondents with respect to RBIS use. Therefore, both data sets were combined, bringing the total respondents to 122 (response rate: 13.2%). Demographics of the 122 respondents are shown in Table I in comparison to nationwide demographics [30]. Given...
the size of the sample, respondent demographics are comparable to national percentages.

D. Limitations

The survey methodology has at least two limitations, each of which is likely to overestimate actual levels of RBIS awareness and use among ECE faculty members.

The first is fidelity. When faculty members self-report that they are teaching using an RBIS, what they are actually doing in the classroom may not reflect the characteristics that the RBIS developer indicated should be used. Studies in undergraduate biology and physics education have found that many faculty members overestimated their use of methods other than lecturing [21], [31]–[33]. It is reasonable to assume similar results in this study.

The second limitation is response bias. With a usable response rate of 13.2%, survey responses may not be representative of the instructional strategies of the broader ECE faculty. In general, it is difficult to estimate the degree to which response bias has skewed the results of any survey because survey analysts typically do not have data on the individuals who did not respond.

Given this constraint, several precautions were taken to understand and reduce response bias. First, the research team followed established practices for increasing response rates when working with professionals [34]. Second, a common method of estimating response bias is to compare characteristics of the respondents to the general population, and if they are similar, conclude that the effects of response bias are reduced [35]. Based on similarity between demographics of survey respondents and national ECE faculty demographics, there is some confidence in the value of the survey results. Third, following established practice, the survey team followed up and contacted additional ECE faculty members who did not respond to the first rounds of surveys, as a way to compare early and late responders to estimate effects of response bias [36]. No differences were found between early and late responders that would indicate that response bias influenced results. Finally, results of this survey are compared to similar studies, and many of the same trends are evident.

The authors think it is reasonable to assume that the ECE faculty members who took the time to respond to this survey about undergraduate education are more interested in the topic than the general population of ECE faculty members. This would mean that they are better informed and perhaps more experienced with the RBIS under study, and that they would respond more positively about RBIS awareness and use. In addition, when asking about use of RBISs, survey items were placed in the same order so that the first response option was “I currently use it.” Lack of randomized ordering may have contributed to bias about awareness and use of RBISs.

As a result, the percentages of ECE faculty members using RBISs are better thought of as upper bounds than representative usages. The data are more useful in examining relative levels and relationships between the RBISs, e.g., which RBISs are in wider use than others. Finally, the section on barriers to adoption of RBISs is likely to be very relevant to the general ECE faculty since similar barriers have been described in research on use of RBISs in other disciplines. For these reasons, the authors propose that the results described in this paper can be used, with care, in thinking about adoption of these instructional strategies across ECE faculty members.

IV. Reported Awareness by Named Research-Based Instruction Strategy

This section presents results on awareness of RBISs among ECE faculty; Section V presents results on use.

Before ECE faculty members can use a specific RBIS, they must learn of its existence. Fig. 2 shows each of the RBISs in descending order of familiarity. Percentages of familiarity ranged from 93% (collaborative learning) to 50% (just-in-time teaching). Familiarity is at or above 69% for all but two of the RBISs: thinking aloud-paired problem solving and just-in-time teaching. Active learning and collaborative learning would be expected to be the highest because they embrace many different teaching approaches and they have been published for decades in many different venues. Awareness levels of RBISs such as thinking aloud-paired problem solving, concept tests, and peer

<table>
<thead>
<tr>
<th>TABLE I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics of Survey Respondents</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Assistant Professors</th>
<th>Associate Professors</th>
<th>Full Professors</th>
<th>Non-tenure-track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>119 respondents provided gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>121 respondents provided rank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey</td>
<td>20</td>
<td>27</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>Nationwide</td>
<td>14%</td>
<td>22%</td>
<td>32%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Fig. 2. Percentages of awareness of RBISs among ECE faculty members teaching core ECE courses.
instruction would be expected to be lower because they are specific teaching approaches and are newer than active or collaborative learning. Even if the actual levels are not quite as high as these survey results, awareness of RBISs appears to be sufficiently high that adoption would be primarily determined by whether ECE faculty members decide to apply the strategies they know about. This finding of high levels of awareness is consistent with the results from the study of physics faculty members [21], [29].

V. REPORTED USE BY RESEARCH-BASED INSTRUCTION STRATEGY

Fig. 3 summarizes use of RBISs, specifically within the subset of respondents who indicated they were familiar with the RBISs. The RBISs are listed in descending order of “ever used” (Traded + Currently Use). Relative ranking of the RBISs generally follows that of awareness in Fig. 2, with a few notable exceptions. Just-in-time teaching moved up significantly, while case-based teaching moved down significantly. As this is a comparison of awareness to trial, these two RBISs have characteristics that influence faculty members’ willingness to try them in their engineering science courses. Just-in-time teaching was developed specifically for large lecture introductory courses (and associated materials may be more readily available), while case-based teaching is a more obvious fit to upper-division engineering courses. This explanation holds also for additional RBISs, which shifted less dramatically in their relative ranking between Figs. 2 and 3. Inquiry learning and thinking aloud-paired problem solving, developed for introductory courses, moved up in the ranking. Project-based learning and service learning moved down since, while being used somewhat in engineering science courses, they may be more prevalent in first-year and capstone courses.

There may be a different set of characteristics that influences whether faculty members will continue to use an RBIS after they try it. To take into account varying percentages of ECE faculty members who have tried an RBIS (as opposed to the percentages who were familiar with an RBIS, which provide the denominators for the percentages in Fig. 3), Table II shows the percentage of ECE faculty members who have tried and stopped (based on a total of current users + those who have tried and stopped). Similar to the results from the study of physics faculty [21], [29], these results clearly show that discontinuation after initial trial of an RBIS is a significant contributor to low levels of use. Further comparisons between findings of a survey of physics faculty members and of this survey of electrical and chemical engineering faculty members are detailed in another paper [37]. Using this percentage, RBISs with very high rates of discontinuation are service learning (76%) and case-based teaching (75%), while the RBIS with the lowest rates of discontinuation is active learning (25%). This would be consistent with the characteristics of these teaching approaches since preparation time and resources required for service learning and case-based teaching are high, while preparation time and resources for active learning are among the lowest of all RBISs. However, it is important to understand whether ECE faculty members perceive these same barriers in making their decisions to try, or continue, an RBIS.

VI. REPORTED BARRIERS TO ADOPTION

The survey provided respondents with the opportunity to describe barriers to adoption for each of the 12 RBISs. Responses were coded, grouped into categories, and the number of responses counted. Since a respondent might list the same barrier for each RBIS, the total number of times a barrier could be mentioned is the number of respondents (122) times the number of RBISs (12): 1464. Aggregate results are presented since there was little variation by specific RBIS. Six categories were most frequently mentioned, and the results are summarized in Fig. 4. The most frequently mentioned barrier is concern that use of an RBIS will consume class time. Class time is mentioned 407 times, or 28% of the possible mentions. The authors infer that respondents are concerned that use of class time is a threat to content coverage, which prior work has identified as a principal concern of faculty members about using an RBIS [32]. The second
most frequently mentioned barrier is preparation time (249 mentions, or 17% of the possible mentions). These two are the most frequently mentioned barriers by chemical engineering faculty members [28] and physics faculty members [21], [29]. Surprisingly, the least frequently mentioned concern is resources (other than time), which was mentioned only 34 times, or 2% of the possible mentions.

Mentions of lack of evidence might be indicative of respondent unfamiliarity with the literature, given the number of different studies across multiple contexts.

Discussions of faculty change inevitably include calls to alter faculty reward systems to help promote adoption of teaching approaches other than lecture [15]. Thus, faculty reward systems would be expected to have been identified as an important barrier in these results. In fact, faculty reward systems were not mentioned as a major barrier by survey respondents. Administration (“My department and administration would not value it”) was the fifth most frequently indicated barrier in the survey, cited less than 2/3 as frequently as these others (Fig. 4). Respondents also had opportunities to identify faculty rewards as barriers to adopting RBISs through open-ended responses. However, only two (see below) mentioned that lack of recognition inhibited adoption of one or more RBIS. On the other hand, the second most frequently cited barrier is preparation time. Class preparation competes for faculty time against research and other activities. If ECE faculty members think they should attend to activities that will produce results more valued by the reward system (e.g., research proposals, journal papers), then it could appear in the survey results as a high frequency of “Too much advance preparation time required.” Yet, it is worth noting that barriers related to class time, evidence of RBIS efficacy, and student resistance were more salient than some of these indicators of the faculty reward system.

To provide more in-depth understanding about barriers ECE faculty mention with respect to using RBISs, for each RBIS the survey asked an open-ended question: “Please specify any factors that seriously discourage any potential plans for using this particular teaching strategy in the future: [each RBIS].” For each RBIS, only five to eight respondents provided open-ended responses. Issues, other than those already listed in the survey, that were raised by multiple respondents include the following.

- Five respondents mentioned that large enrollment courses hinder use of one or more of the RBISs.
- Two respondents mentioned that they would be more likely to try one or more RBISs if they received recognition for their initiative, e.g., in their annual review.
- Two respondents mentioned student resistance. One said that students complained because attendance became more important if an RBIS was being used. Another said that “stronger students pushed back” against RBIS implementation.

Also, some respondents understood one or more of the RBISs in ways that were at odds with more commonly accepted interpretations. For example, when asked about factors that would discourage implementation of active learning, one respondent mentioned the cost of clicker systems. Since active learning can be implemented in many ways that do not require clicker hardware, this respondent may have interpreted active learning more narrowly than interpretations that are presented in many papers on active learning. This perception of active learning as requiring costly equipment is consistent with results of the authors’ prior study of engineering department heads [38].

VII. DISCUSSION AND CONCLUSION

Awareness levels for the 12 RBISs were high, reinforcing previous findings that significant barriers to broader adoption occur at later stages in the process as faculty members consider whether to try, and later continue or discontinue, using a specific RBIS [21], [28], [29].

There was far more variation across the RBISs in levels of use and percentages of faculty who had tried but abandoned different RBISs (discontinuation). Active and collaborative learning had the highest levels of awareness and use and the lowest rates of discontinuation. These two RBISs have been documented in the literature for the greatest length of time and require few resources to implement. Inquiry learning and problem-based learning had high awareness and use, but roughly 50% discontinuation. Service learning and case-based teaching had the highest rates of discontinuation, 75% or more. Percentages of current use for both are below 10%, suggesting that only innovators and less than half of early adopters are applying either in their courses. These two RBIS require significant resources, including instructor time, and current curricular materials do not support their use in the core engineering science courses in this study.

Although respondents had the option to indicate different barriers for different RBISs, there were few deviations from the overall trend in Fig. 4. Class time was by far the most frequently cited barrier. To address this barrier, advocates of one or more RBISs would address faculty members’ perceptions of the time required to apply these instructional strategies. The literature varies in its claims of how much class time various RBISs will take, in part because this depends on how faculty members
choose to implement them. The issue may be more complex than simply repairing faculty misperceptions.

A more important result related to barriers was that there was limited evidence to support the widely touted notion that the faculty reward system is the primary barrier to improving instruction in undergraduate engineering education. Only two respondents wrote open-ended comments related to credit for teaching improvements in their annual reviews. Rewards and values may manifest themselves in pressures on how to spend one’s limited time, particularly class preparation time, which could be spent on research instead. However, this barrier was a distant second to concerns about class time, and pressure from administrators was fifth after lack of evidence and student resistance. These results suggest that faculty members’ orientation toward content coverage and their beliefs about student learning are more critical barriers to widespread adoption than promotion and tenure.

Based on the rates of current use presented in Fig. 3, ranging from 8% to 69%, these RBISs span the S-curve presented in Fig. 1. At 69% and 55%, active and collaborative learning are farthest along and arguably past the 50% tipping point that presages widespread adoption. Both have been documented in the literature since at least 1981. In contrast, thinking aloud-paired problem solving (TAPPS) has been documented for at least as long, but does not seemed to have gained traction in ECE (23% of respondents currently use it). This low rate of use, coupled with its 55% discontinuation rate, may indicate that TAPPS’s adoption curve in ECE will more closely resemble Fig. 1(b). Case-based teaching and service learning are more recent developments, but their discontinuation rates (in excess of 75%) argue against their widespread adoption, at least in core ECE engineering science courses. Current use and discontinuation rates for other RBISs, such as just-in-time teaching and concept tests, make predictions about adoption questionable, even as developers are actively working to create and archive engineering-specific resources for use in engineering science courses.

Of course, predictive inferences should be interpreted cautiously, as suspected response bias suggests that actual rates of awareness and use of RBISs by ECE faculty are lower than presented in this paper. Future work should take into consideration challenges described in this paper to estimate rates of adoption of RBIS in undergraduate education. Some analyses can be designed so that they do not rely on generalizable adoption rates, such as examining relationships between other variables. Nonetheless, survey results presented here are a starting point, providing some empirical data and links to theory and literature, to foster increasingly sophisticated discussions and investigations of instructional practice in undergraduate STEM education.

ACKNOWLEDGMENT

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors wish to thank Dr. S. Lord and the Virginia Tech Center for Survey Research for their partnership and assistance on this project.

REFERENCES


Jeffrey E. Froyd (M’78–SM’99–F’12) received the B.S. degree in mathematics from the Rose-Hulman Institute of Technology, Terre Haute, IN, USA, in 1975, and the M.S. and Ph.D. degrees in electrical engineering from the University of Minnesota, Minneapolis, MN, USA, in 1976 and 1979, respectively.

He is a TEES Research Professor in Engineering Student Services and Academic Programs with Texas A&M University, College Station, TX, USA. Prior to this, he was an Assistant Professor, Associate Professor, and Professor of electrical and computer engineering with the Rose-Hulman Institute of Technology. He served as Project Director for the Foundation Coalition, a National Science Foundation (NSF) Engineering Education Coalition in which six institutions systematically renewed, assessed, and institutionalized their undergraduate engineering curricula, and extensively shared their results with the engineering education community. He has authored over 70 papers on faculty development, curricular change processes, curriculum redesign, and assessment.

Prof. Froyd is a Fellow of the American Society for Engineering Education, an ABET Program Evaluator, and a Senior Associate Editor for the Journal of Engineering Education. He has served as the General Chair for the 2009 Frontiers in Education Conference and a Program Co-Chair for the 2003, 2004, and 2011 Frontiers in Education conferences. At Rose-Hulman, he co-created (with Brian Winkel) the Integrated, First-Year Curriculum in Science, Engineering and Mathematics, which was recognized in 1997 with a Hesburgh Award Certificate of Excellence.

Maura Borrego received the B.S. degree from the University of Wisconsin—Madison, Madison, WI, USA, in 1998, and the M.S. and Ph.D. degrees from Stanford University, Stanford, CA, USA, in 2001 and 2003, respectively, all in materials science and engineering.

She is an Associate Professor of engineering education with Virginia Tech, Blacksburg, VA, USA, currently serving as a Program Director with the Division of Undergraduate Education, US National Science Foundation, Arlington, VA, USA. She is an Associate Editor for Journal of Engineering Education. As a doctoral student, she studied adhesion of polymers for microelectronic packaging applications. Her current research interests include change in higher education, faculty use of research-based instructional strategies (RBIs), and interdisciplinary collaboration among graduate students and faculty members.

Dr. Borrego is Chair of the Educational Research and Methods Division of the American Society for Engineering Education and North American Representative to the Research in Engineering Education Network Board.

Stephanie Cutler received the B.S. degree in mechanical engineering from Virginia Commonwealth University, Richmond, VA, USA, in 2008, and the M.S. degree in industrial and systems engineering with a concentration in human factors from Virginia Tech, Blacksburg, VA, USA, in 2012, and is expected to receive the Ph.D. degree in engineering education from Virginia Tech in 2013. Her dissertation investigates faculty decision making in the Statics classroom, focusing on faculty members’ decisions about using research-based instructional strategies (RBIs) when teaching statics.

She currently works as a Graduate Research Assistant under the direction of Dr. Maura Borrego. She previously held positions as a Graduate Teaching Assistant, and from 2009 to 2011, she participated in the National Science Foundation Integrated Graduate Education and Research Traineeship (IGERT) program as a Fellow. Dr. Cutler has been a member of the American Society for Engineering Education (ASEE) since 2009. She was also a founding member of the Graduate Engineering Education Consortium of Students (GEECS).

Charles Henderson received the B.A. degree in mathematics and physics from Macalester College, St. Paul, MN, USA, in 1991, and the M.S. degree in physics and Ph.D. degree in curriculum and instruction from the University of Minnesota, Twin Cities, Minneapolis, MN, USA, in 1994 and 2002, respectively. He is an Associate Professor with Western Michigan University, Kalamazoo, MI, USA, with a joint appointment between the Physics Department and the Mallinson Institute for Science Education. He is the Senior Editor of Physical Review Special Topics—Physics Education Research. Much of his research activity is focused on understanding and improving the slow incorporation of research-based instructional reforms into college-level STEM courses.

Michael J. Prince received the B.S. degree from Worcester Polytechnic Institute, Worcester, MA, USA, in 1984, and the Ph.D. degree from the University of California, Berkeley, CA, USA, in 1989, both in chemical engineering.

He is a Professor of chemical engineering and Rooke Professor of Engineering with Bucknell University, Lewisburg, PA, USA, where he has been since 1989. He is also co-Director of the National Effective Teaching Institute and “How to Engineer Engineering Education,” both well-established workshops that attract a national audience of engineering faculty each year. He is the author of several education-related papers for engineering faculty and has given over 100 faculty development workshops to local, national, and international audiences. His current research examines how to repair persistent student misconceptions in heat transfer and thermodynamics as well as the relationship between classroom climate and students’ development as self-directed, lifelong learners. His work also examines how to increase the use of research-supported instructional strategies by engineering faculty by identifying barriers to the adoption of new teaching methods.

Dr. Prince is a member of the American Society for Engineering Education. His educational accomplishments have been recognized with several awards. In 2012, he was invited to be the C. P. Phillips Lecturer in Chemical Engineering Education at Oklahoma State University, Stillwater, OK, USA, and was awarded the Robert L. Rooke Professorship in Engineering at Bucknell University. He also received the Hutchison Medal from the Institution of Chemical Engineers in 2009, Bucknell University’s Lindback Award for Distinguished Teaching in 2008, and was honored in 2004 with the American Society of Engineering Education’s Mid-Atlantic Section Outstanding Teaching Award.