Faculty Use of Research Based Instructional Strategies

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Abstract: *Over the last 20 years, significant investments (individual, institutional, state, and federal) have been made to improve engineering education. Multiple Research Based Instructional Strategies (RBIS) have been developed and shown to improve student learning. In order to assess engineering faculty members' awareness and use of these strategies, a survey was developed and distributed through chemical and electrical engineering professional societies targeting academic staff teaching core required courses. Just over 200 electrical and chemical engineering faculty in the US completed the survey. Results show that faculty members most commonly learn about RBIS from colleagues (18%). 98.6% of faculty report knowledge about one or more of the 12 RBIS asked about in the survey. 82.1% of faculty report use of one or more of these RBIS. The most common reason given for non-use was the fear that these strategies would take up too much class time.*

Introduction

A number of recent editorials and reports call for action to translate engineering education research and innovation into improved learning and productivity for the approximately 22,000 engineering faculty and approximately 600,000 engineering students in the U.S. (Fincher, 2009; Jamieson & Lohmann, 2009; NSF, 2010; Watson, 2009). One significant set of approaches has been Research-Based Instructional Strategies (RBIS) such as active learning (Prince, 2004), cooperative learning (Prince, 2004), problem-based learning (Prince & Felder, 2006), and service learning (Oakes, 2009). Despite investments over 20 years, as noted in recent reports, propagating RBIS from originating faculty members and innovative adopters (Rogers, 2003) to more widespread use requires additional attention (Ertmer, 1999). To better understand the extent to which RBIS are being applied, this study looks at how chemical and electrical engineering faculty members are learning about and using RBIS in core, required engineering science courses. These courses are usually taken in the sophomore year, and should be distinguished from first-year engineering courses and senior capstone design courses that have been substantially redesigned in a number of initiatives that have taken place since 1990.

Although many RBIS have been developed, this study will focus on a subset (shown in Table 1) that meet the following criteria: (1) RBIS should have documented use in engineering settings at more than one institution (2) RBIS should have demonstrated positive influence on student learning in engineering or STEM.

Research Questions

For this paper, the research question investigated is:

> What are the self-reported levels of knowledge and use of RBIS from engineering faculty members teaching core engineering science courses?

Table 1: Research Based Instructional Strategies (RBIS) and descriptions used in survey

RBIS	Brief Description	Reference
Active Learning	A very general term describing anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes.	(Prince, 2004)
Think-Pair-Share	Posing a problem or question, having students work on it individually for a short time and then forming pairs and reconciling their solutions. After that, calling on students to share their responses.	(Felder & Brent, 2009)
Concept Tests	Asking multiple-choice conceptual questions with distracters (incorrect responses) that reflect common student misconceptions.	(Felder & Brent, 2009)
Thinking-Aloud-Paired Problem Solving (TAPPS)	Forming pairs in which one student works through a problem while the other questions the problem solver in an attempt to get them to clarify their thinking.	(Felder & Brent, 2009)
Cooperative Learning	A structured form of group work where students pursue common goals while being assessed individually.	((Millis & Cottell, 1998); Prince, 2004)
Collaborative Learning	Asking students to work together in small groups toward a common goal.	(McNamee, Roberts, & Williams, N.D.)
Problem-Based Learning (PBL)	Acting primarily as a facilitator and placing students in self-directed teams to solve open-ended problems that require significant learning of new course material.	(Prince & Felder, 2007)
Case-Based Teaching	Asking students to analyze case studies of historical or hypothetical situations that involve solving problems and/or making decisions.	(Prince & Felder, 2007)
Just-In-Time Teaching	Asking students to individually complete homework assignments a few hours before class, reading through their answers before class and adjusting the lessons accordingly.	(Novak, Patterson, Gavrin, & Christian, 1999; Rozycki, 1999)
Peer Instruction	A specific way of using concept tests in which the instructor poses the conceptual question in class and then shares the distribution of responses with the class (possibly using a classroom response system or "clickers"). Students form pairs, discuss their answers, and then vote again.	(Mazur, 1997)
Inquiry Learning	Introducing a lesson by presenting students with questions, problems or a set of observations and using this to drive the desired learning.	(Kolb, 1984)
Service Learning	Intentionally integrating community service experiences into academic courses to enhance the learning of the core content and to give students broader learning opportunities about themselves and society at large.	(Oakes, 2009)

Methods

Since the intent of the study was to look at the extent of RBIS application across all engineering programs in the United States, survey methodology was selected to provide information over a breadth of programs. The survey was delivered to faculty who had recently taught an introductory electrical or chemical engineering course. In an attempt to improve the response rate, the survey was distributed by appropriate education chairs of the American Institute of Chemical Engineers (AIChE) and the Institute for Electrical and Electronics Engineers (IEEE) societies, and gift cards were offered as raffle incentives. There were 133 chemical and 177 electrical and computer engineering responses. 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 93 chemical and 115 electrical and computer engineers who completed the survey for a total n of 208. Approximately 1,500 faculty were contacted through the professional organizations and with 208 respondents, our response rate is approximately 14%. Of the 208 who completed the survey, 19% were female and 80% male (with 4 participants not responding to this question); 16 (7.7%) were lecturers (i.e., not tenure track), 60 (29%) assistant professors, 57 (27%) associate professors, 67 (32%) full professors, and 6 (2.9%) administrators (with 2 participants who did not respond to this question).

Results

Faculty members were asked about their degree of knowledge and use of the different RBIS listed in Table 1; with seven options between “I currently use [the RBIS]” and “I have not heard of it”. Figure 1 shows percentage (of the total responses, n=208) of faculty who are currently using, have used, and have not heard of each RBIS. Active learning (n = 127; 61%) and collaborative learning (n = 119; 57%) were reported as being used the most. This may be because (i) both have been advocated in the literature for over twenty years, (ii) both have a considerable literature base supporting their efficacy, and (iii) many other RBIS have components that are consistent with active learning and collaborative learning, so using some of the other activities could be examples of using active learning or collaborative learning (Felder & Brent, 2009; Prince, 2004). Thinking-Aloud-Paired Problem Solving (TAPPS) (n = 71; 34.1%) and Just in Time Teaching (JiTT) (n = 70; 33.7%) were the least known RBIS. Service Learning and Case-based Teaching have a higher percentage of past users (n = 28; 14% and n = 39; 19% respectively) than current users (n = 11; 5.3% and n = 25; 12% respectively).

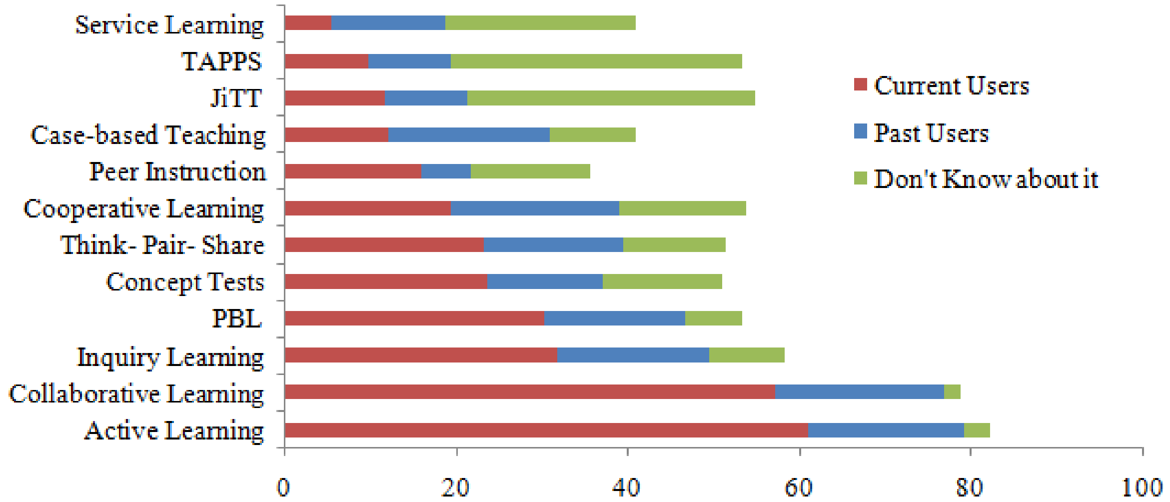

Figure 1: Faculty who are currently using, have used, and do not know about the different RBIS as a percentage of total respondants

If participants responded that they knew of a RBIS, they were asked a series of questions about how they first heard of the strategy, how they acquired new information about the strategy, and what factors discouraged their use of the RBIS. Summaries of responses to these questions are shown in Figures 2 and 3. The number of responses in these figures represent repeated responses by individual participants based on their knowledge of different RBIS.

Figure 2 displays percentages of respondents who recalled a specific method about how faculty learned about as well as gather more information about each RBIS. For how participants found more information in Figure 2, participants were allowed to mark multiple responses for each RBIS they had knowledge of, making for a larger number of possible responses for each option; this was also true for Figure 3.

Faculty members first heard of RBIS in a number of different ways, but many of them did not recall the specific method of discovery (n = 690). Of those who recalled how they found a RBIS (Figure 2), collegues (word of mouth) (n = 346; 29% of those who recalled), campus workshops (n = 269; 23%), and reading an article/book (n = 263; 22%) were the most highly cited techniques. Disciplinary professional society conferences/workshops (n = 53; 4.4%) was cited the least.

To find more information about the RBIS, the faculty went to a number of sources. A large number of respondents did not remember how they found new information (n = 598). Of those who did recall (Figure 2), faculty members said they either read a a journal article or book (n = 669; 27% of those who recalled), followed by collegues (word of mouth) (n = 565; 22.4%). Professional society conferences (n = 211; 8.4%) and off campus workshops (such as the National Effective Teaching Institute (NETI) or an NSF-sponsored workshop) (n = 223; 8.9%) were cited the least often.

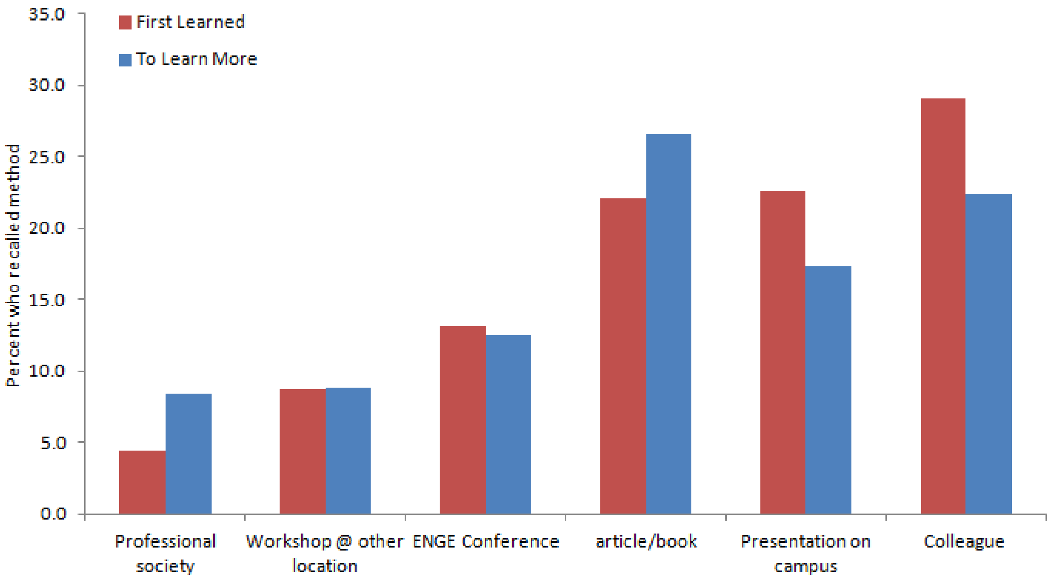

Figure 2: How faculty first heard about and gathered more information about RBIS

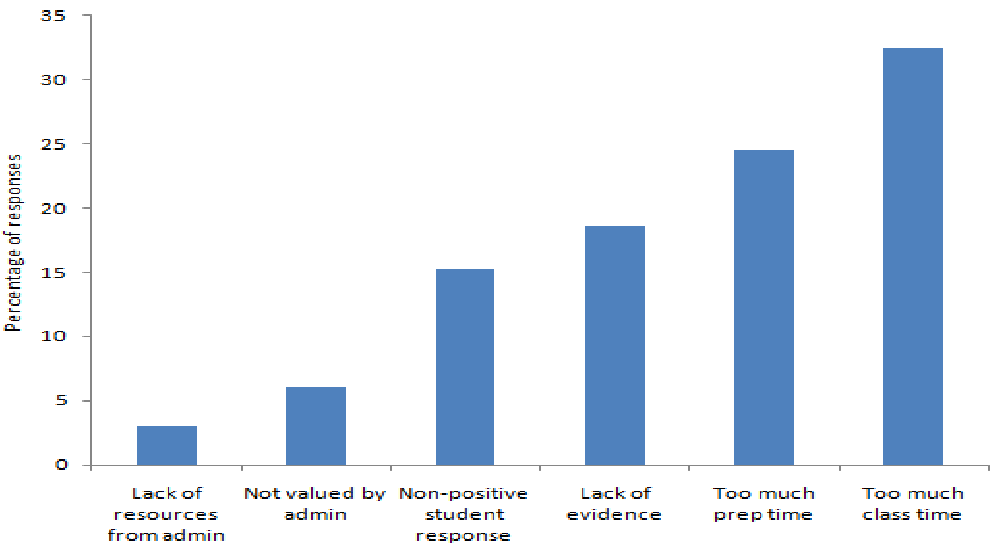

Figure 3 : Reported barriers to using RBIS

Finally, factors that participants gave in response to a question about what factors hindered them from using the RBIS, these were labeled as barriers. Time was the largest barrier identified, both in the class room by limiting the time to cover the course material (n = 737; 33% of the total responses about barriers) and before class in terms of preparation time (n = 558; 25%). This is consistent with previous findings (Henderson & Dancy, 2007). After time, the most cited barrier was a lack of evidence to support the efficacy of the RBIS (n = 423; 19%). Given the number of studies that support the efficacy of many RBIS, this barrier reveals the degree to which many engineering faculty members are unaware of the literature. The least cited barrier was a lack of departmental resources to support the instructional strategy (n = 68; 3.0%). These results can be seen in Figure 3.

Discussion

The preliminary survey results presented here suggest that a majority of faculty members have at least some knowledge of most of the RBIS we examined in this study. Almost all (99%) participants report knowing about one or more of these strategies. Active learning and collaborative learning were reported as being used by approximately half of the sample. This is thought to reflect the overarching nature of these RBIS and that many of the other strategies incorporate a number of the same aspects present with active and collaborative learning.

Many faculty members did not recall how they first heard about a specific RBIS, but did recall consulting books or articles and colleagues for more information. Not recalling the initial source of the contact may have been due to having multiple points of exposure around the same time or the discovery was made many years ago. More thorough investigation into the process faculty take when integrating RBIS into the classroom will be completed as part of future work.

Limitations

One limitation of this study is that only two engineering disciplines were sampled. The results from this study cannot be generalized to all disciplines, although preliminary analysis suggests there are not large differences between electrical and chemical engineering responses. This will be further investigated in future work.

Another limitation of this study is that there is a suspected bias within the sample to people who are aware and use RBIS due to a low response rate. Many of the respondents had heard of at least one RBIS and over half of the sample is currently using at least one RBIS in their classroom. One of the next steps for this study is to attempt to contact non-respondents and see if their responses are similar to the respondents.

Conclusion

This paper shows preliminary results from a survey of US electrical and chemical engineering academic staff investigating their knowledge and use of different RBIS. Several conclusions can be made.

First, results show that active and cooperative learning are the most widely used of the 12 RBIS asked about in the survey. This is consistent with their generality and consistent advocacy in conference papers, workshops, and evidence supporting the efficacy of these methods.

Second, engineering faculty members most often learn about RBIS from colleagues. This is consistent with other research on technology transfer and knowledge management that has found that "technology transfer is a contact sport" (Rogers, 2003), meaning that transfer of complex, practice-oriented knowledge propagates through personal networks, not channels through which research results are published, e.g., journal articles and conference papers. However, these channels are the most common ways for those interested to learn more about RBIS.

Third, engineering faculty members indicate that time to apply these approaches is the largest barrier to use. This consistent with both other studies of barriers to use of alternative teaching approaches (Dancy & Henderson, 2010) as well as studies of barriers to technology transfer and change.

Implications and Future Work

One implication for this work is aiding researchers in disseminating their RBIS research. Publications are an important element of dissemination; however more needs to be done to help communicate with the faculty implementing the RBIS. Encouraging peer discussion, in addition to providing books and articles, will help raise awareness and hopefully the implementation rate of the new RBIS.

Another implication is to find approaches to share the many studies demonstrating improved student learning through RBIS, since this survey shows lack of this knowledge as the second most frequently cited barrier. Publishing articles in academic journals alone has not informed judgments by the engineering faculty members who were surveyed.

Following this work, further investigation into academic staff decisions to use RBIS will be conducted as well as a comparison between what the staff report spending time on in the classroom as compared to their reported use of the RBIS and the activities associated with them. Disciplinary comparisons will also be made and an effort to start incorporating the additional engineering core course of statics in further investigation.

This quantitative study is the first stage of a mixed methods study. Two qualitative case studies will be completed to further investigate what is happening in the classroom and the decisions that are being made by faculty.

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