Student Perceptions of Instructional Change in Engineering Courses: A Pilot Study

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Abstract

Engineering and science professors have been provided strong evidence that Research-Based Instructional Strategies (RBIS), such as active learning, are effective in increasing student learning, yet the rate of adoption of such strategies has been slow. While concerns about time management and lack of support from administration commonly discourage the adoption of RBIS, students' potentially negative reaction to a new teaching method is another important barrier. Research has shown that students can perceive a new teaching method, like group discussions, as being unhelpful while assessment evidence indicates that the method results in learning gains. Expectation Violation theory predicts that if a class differs from a students' expectations (i.e., typically a lecture), the student will resist the instructional strategy and thereby limit its effectiveness. We propose that a proper understanding of what an incoming engineering student anticipates from a college classroom will help a professor transition to using a RBIS more smoothly. In this pilot study, focus groups were conducted with undergraduate engineering students to discuss their experiences and expectations for transitioning to college engineering classes.

Introduction

Tremendous effort and funding have been invested to improve engineering education by developing and documenting the effectiveness of RBIS such as active learning[1], peer instruction[2], and Peer-Led Team Learning (PLTL)[3]. This investment over the past few decades has successfully shown that specific teaching practices can, in fact, improve student learning, engagement and interest in engineering[4-7]. Many of these teaching practices are especially effective for educating a diverse student body[4,5] and for increasing the retention rate of students in STEM programs[4,8-10].

In spite of the ample evidence of their effectiveness, the adoption of these practices has been slow and not necessarily persistent[11-16]. Our own research with instructors in electrical/chemical engineering[17] and introductory physics instructors[18] confirms that more than one-third of faculty who have tried to implement one or more nontraditional teaching methods discontinue their use (e.g., Figure 1).

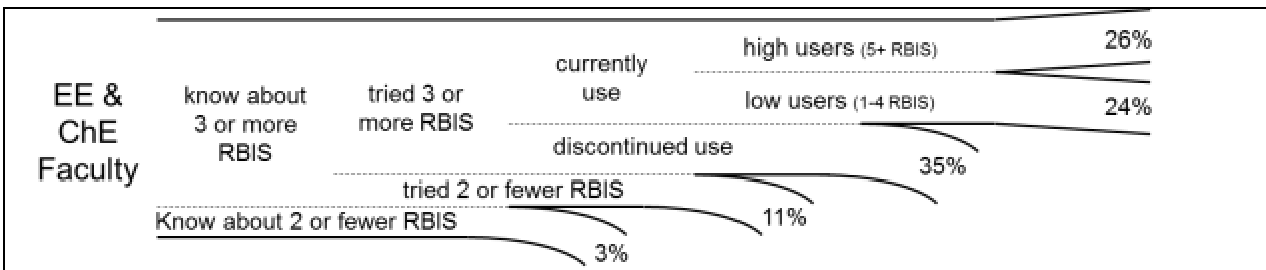

Figure 1. The largest group of faculty (35%) have tried nontraditional teaching methods and then discontinued their use

Research has identified a number of barriers to the use of these nontraditional teaching methods, such as instructor concerns about preparation time or the ability to cover the required syllabus. Of the reported concerns, perhaps the one most requiring additional research is student resistance[19-24]. Student resistance describes the negative student response or pushback to nontraditional instructional methods. Weimer[25] ascribes student resistance to the fact that active learning methods generally require more work on the part of the student, cause anxiety about students' ability to succeed in a new environment, and occasionally set expectations that students are not yet prepared to meet. In addition, students often judge (incorrectly) that nontraditional methods lead to decreased learning. In two different studies, students perceived that they did not learn as much from group discussions[26] and problem-based learning[27] as they would have from traditional lectures, despite assessment evidence to the contrary. This mismatch between learning gains and student affective responses may be an important key to understanding why, in the face of strong evidence of learning gains, STEM faculty are not comfortable with adopting nontraditional teaching methods.

This study approaches student resistance using expectancy violation theory[28-31], which posits that students have a negative reaction to teaching methods that they have not encountered before. Though, student reactions to novel teaching methods do not have to be negative in every case. The literature on student affective responses to nontraditional teaching methods is largely inconclusive. This is in part because so many different measures have been used to measure student response, including engagement and satisfaction[32], attitude and motivation[33,34], instructor quality[26,33], and students' perceptions of impact on their learning[26,27,35,36]. Other studies used end-of-course student evaluations of teaching to assess students' response[36-38]. Of 18 reported studies of the effect of active learning on student evaluations, half found positive student reactions while the other half found mixed or negative student reactions, as summarized below:

- Overall positive affective student responses (*n* = 9 articles)[32,33,35-41]
- Mixed affective student responses (i.e., positive on some measures/activities, negative on others)(*n* = 7 articles)[34,42-47]
- Negative affective student responses (*n* = 2 articles)[26,27]

These findings suggest that there are ways to implement nontraditional teaching methods that do not lead to significant student resistance, but that instructors need strategies to minimize problems. The literature offers a variety of tips for faculty wishing to reduce student resistance to nontraditional teaching methods [26,48-57] and Table 1 summarizes some of this advice.

Table 1. Advice from literature to faculty implementing nontraditional teaching methods.

• Clearly explain expectations[43,58]
• Explain and reinforce the purpose[34]
• Acknowledge the challenges of the new approach[27]
• Use nontraditional teaching methods in as described in research[35]
• Provide students with feedback, support, & scaffolding[27,59]
• Explain effect on grade [60] and align activities with assessments[27,59,60]
• Solicit student feedback[27]
• Ramp up slowly, e.g. use brief activities at first[33]
• Assign/design appropriately challenging activities[32,34,58,60]
• Respect student learning styles and study habits[59]

These suggestions tend to be drawn from personal experience, rather than from strong empirical and theoretical bases. This reflects that although connections between expectancy violations and student resistance to nontraditional teaching have been asserted, the link between these two constructs has not been rigorously tested. Thus, another goal of our project is to rigorously establish the link between students' expectations and student resistance.

We have recently been awarded a National Science Foundation grant to study student resistance to nontraditional teaching methods through a range of observations, surveys, interviews, and focus groups capturing both student and faculty perspectives. In this paper, we focus on the insights into student resistance that can be gained by interviewing students in a focus group setting. We compare the results of focus groups conducted at two institutions using two similar sets of questions. We reflect on both the different insights from two different populations of students, differences in the focus group protocols, and the benefits and limitations of interviewing students to gain insight into student resistance. Our research question is:

What insights about student resistance can be gained from focus groups with undergraduate engineering students?

Focus groups may be viewed as a "purposeful conversations in which one person asks prepared questions and another answers them"[61]. Student focus groups provide an opportunity to gather rich data about student experiences and attitudes. Indeed, for affective outcomes such as student attitudes—including student resistance—focus groups provide a direct assessment of the desired outcome. Compared to other assessment tools such as surveys, focus groups allow the researcher to go into more depth on any specific topic or to explore novel questions that arise in the course of the initial discussion that were not originally anticipated in the study design. Focus groups therefore "allow for the collection of preliminary information about a topic. They may be used in pilot studies to detect ideas that will be further investigated using another research method"[62]. Focus groups can be particularly effective for purposes of developing or validating observation protocols or other more quantitative assessment instruments[63].

Focus groups, like all assessment methods, have limitations. They can be time and resource intensive, although less so than individual student interviews. Care must also be taken to avoid selection bias in which participants agree to participate because they have unusually strong opinions. Group dynamics can also influence student response, especially if strong personalities dominate the conversation. However, participant interactions can also spark new insights among the participants or help to draw out comments from otherwise quiet individuals [64]. Finally, as with much qualitative research, it can be challenging to generalize findings from focus groups to a more general population.

Methods

As stated above, we conducted undergraduate student focus groups at two institutions with slightly different protocols.

Site A is a large, highly-selective, public research institution in the Midwest. At site A, we conducted student focus groups to collect additional information following a student survey about supportive teaching practices[65]. The survey was completed by 386 engineering undergraduate students, and 11 of them participated in one of four separate focus group sessions. Among other things, the focus group protocol included some items to probe about students' expectations of the classroom, students' perceptions of faculty's expectations, and students' reaction to faculty use of student involvement. Sample items from the focus group protocol include the following:

Q. When you think about a typical engineering lecture-based course, what expectations do you have in terms of your involvement in the class session? In other words, what do you expect to do during a regular class session?
Q. Are there any courses where these expectations were challenged, in other words, where your expectations of your involvement during class were different?
Q. When you think about a typical engineering lecture-based course, what expectations do you think faculty have of you in terms of your involvement in the class session. In other words, what do you think faculty expects you to do during a regular class session?
Q. Are there any courses where these expectations were challenged, in other words, where faculty expectations of your involvement during class were different?
Q. How do you respond when a faculty member tries an instructional style that requires your involvement in class, for example, working with a partner or a team to solve a problem? When a faculty tries something that requires student involvement in class, does it usually work? What if it doesn't work?

Site B is a smaller public institution in the Southeast designated a Historically Black College or University (HBCU). It is designated as the nation's leading producer of African-American engineers. Focus groups were conducted with 9 participants in 3 sessions. Students were all recruited through their introductory materials science and engineering course by their instructor. The focus groups were conducted by researchers visiting from another institution. Most participants were underrepresented minorities, consistent with the HBCU mission of Site B. Sample items from the focus group protocol include:

Q. How would you describe a typical engineering class? What is expected from the students and what is expected from the professors?
Q. If I was sitting in the back of the room during a typical engineering class, what would I see?

Q. Describe what you expected from an engineering course when you first came into college as a freshman.
Q. What sources would you say gave you the best idea of what to expect in college?
Q. Have you ever had a science or engineering course where your instructor tried to do something different? Tell me about what they tried.
Q. What did the students think? How did they react?
Q. What do you wish engineering instructors did in class to help you learn?

We began analyzing the two data sets independently using simple thematic analysis[66]. After we agreed to focus on the benefits and limitations of student focus groups for studying student resistance, two authors who were familiar with the data developed a simplified coding scheme: class environment and student expectations, benefits of nontraditional methods (described by instructors to students), and types of student resistance. Two authors recoded the data into these new categories, which is also the organization of the results section that follows.

Results

Student Expectations

One of the theoretical frameworks guiding our research project is expectancy violation theory, which asserts that students tend to respond negatively when their expectations about instructional methods are violated[28-31]. Therefore, it was important for us to ask what expectations students had for their engineering courses. In all four focus groups at Site A, students reported that they expected to sit, listen, and take notes during class, as exemplified by this student

> I'd say for any given engineering course I would expect to just sit there and listen. Maybe take notes, depending on how good the slides are. That's not always true, and I think that in a better lecture that's not true, but just going into any course, that would be my first expectation of how it's going to work.

In addition, students reported that the faculty generally had the same expectations—they expect students to attend lecture, take notes and pay attention.

Most of students at Site B identified a typical engineering classroom setting in which the students were expected to copy whatever the professor wrote on the board. Students explained that the professor sometimes comes prepared with a fill-in-the-blank PowerPoint presentation or a set of problems to go over in class. One participant noted that not all students were at the same level when it came to understanding, "You would see about three to four people in the front that know exactly what they're doing and about eight people asking them what to do while the teacher is still going on, for sure." Others added to the description that these engineering courses occurred at a fast pace in which every minute is planned:

> Lecturing and doing examples. Yeah, like they'll lecture for a little bit and then they'll do an example problems, lecture to us a little bit, like do just the concept, and then they'll put the concept into an example and then they'll do like an example or two. Then they'll go back to another concept and just keep building on that, day in and day out. So, it's

> very true about half the class doing other things, because I know a lot of people that are [thinking], ‘oh, I don’t learn in this class, I don’t do this, there’s no point in paying attention.’

The question wording used at Site A was particularly effective at getting students to focus on class sessions as opposed to other aspects of their learning: “When you think about a typical engineering lecture-based course, what expectations do you have in terms of your involvement in the class session? In other words, what do you expect to do during a regular class session?” However, it worth noting that the wording used at Site B of “If I was sitting in the back of the room during a typical engineering class, what would I see?” prompted vivid descriptions of different levels of engagement among students depending on where they sat in the classroom. For example, one warned against sitting in the back of the room because as researchers, we would be too distracted by students reading the newspaper and playing games on their computers and phones.

Types of Resistance

In the limited literature on student resistance, the ways that students resist are generally limited to behaviors during class sessions, such as passively refusing to participate or actively voicing disagreement with the assigned activities. However, interviewing students led to identification of some behaviors outside of class that could be included in a definition of student resistance.

One focus group participant at Site A was “a little outraged” when the professor required them to ask relevant questions during class. Others reported that when class involvement was required, sometimes students “wait around until the instructor finally starts writing the answer” or socialize instead of work on the assigned problem. These students group reported that their expectations were challenged when they were required to ask and answer questions in class for participation points. Because the questions were very focused on class sessions, the focus groups did not identify any new types of resistance.

The participants at Site B reported that some students reacted by verbally communicating discomfort with their peers (soliciting agreement and validation for their perceptions) and by dropping the course, perhaps with the intention of retaking it in another term or with another instructor that did not require as much active participation. It is important to note that asking students how others reacted was key to eliciting these responses. Students were aware that the socially desirable response was to support nontraditional and active learning approaches (and generally good students self-selected to participate), so they were far more comfortable describing negative responses if they could attribute them to other students.

Again, the wording of Site A questions focused more on class sessions (“How do you respond when a faculty member tries an instructional style that requires your involvement in class, for example, working with a partner or a team to solve a problem? When a faculty tries something that requires student involvement in class, does it usually work?”) than the wording of Site B questions (“Have you ever had a science or engineering course where your instructor tried to do something different?”).

Strategies to Reduce Student Resistance

Finally, the focus groups helped us identify particularly effective strategies that instructors used to describe nontraditional class activities to students to reduce their resistance. Participants at Site A generally responded positively when active learning exercises were incorporated into the course from the beginning with clear structure and purpose for engaging in the activity—a finding that is consistent with the literature on reducing student resistance. Students' positive responses to instructional changes were primarily attributed to instructor's ability to explain the purpose behind change in classroom engagement. One student stated,

> But I feel if it was done, you know, early in the beginning of the program, everyone would be on the same page as far as how they wanted the teamwork to work, so everyone would be on the same page as you progress through the years.

Participants at Site B tended to emphasize the types of environments that engineers face in their professional work:

> What I'm saying is, you know, if you want to be a successful engineering student, you should already develop learning styles that involve teamwork outside the classroom or inside the classroom if the teacher allows it.

In their many comments to this effect, Site B students frequently attributed these ideas to their instructors, although it was clear that students also believed them. Students understood that in their future jobs they would have to work in teams and acknowledged the benefits of the nontraditional teaching strategies in preparing them for their future jobs as engineers. Another student at Site B described one such incident where the instructor deliberately formed project teams where the members had conflicting schedules so that it would be difficult for everyone to meet up. The student understood the reasoning when the professor provided an explanation behind the implemented change. Quoting the student,

> He told us, after he told us that he had put us in conflicting schedules, he explained to us that, you know, when we have jobs full time that everyone's not going to be able to always meet at the same time, and also everyone might not, and there would be other conflicts as well, like everyone might not get along.

In hindsight, it makes perfect sense for engineering educators to explain how their teaching approaches prepare students for real engineering work. Yet, the literature did not identify this suggestion. As described in Table 1, instructors are suggested to explain the effect of nontraditional instructional approaches on student grades[60], but not to appeal to deeper, mastery orientations of their learning. Nonetheless, these focus groups provided validation of particular strategies for reducing student resistance to nontraditional instructional practices.

Discussion

Our engineering student focus groups confirm several principles of student resistance identified in the literature. First, students have baseline expectations that are consistent with watching a lecture, taking notes and perhaps answering some questions or attempting practice problems. Second, students indeed passively resist by refusing to participate until the instructor offers his or her own response to a posed question. Third, students reinforced many of the suggested strategies for reducing resistance, specifically, integrating the activities from the beginning with clear structure and purpose for engaging in the activity.

These focus groups also helped identify additional information not covered in the limited literature on student resistance. For example, students at Site B were asked how they developed their expectations for college level engineering courses. The answers spanned the range of precollege engineering courses and experiences to television and movies (which depict college courses as boring but the overall college experience as a continuous party). Students at Site B also identified additional types of resistance exercised outside of class sessions, by eliciting agreement and validation for negative attitudes toward nontraditional teaching approaches and by dropping the course. Finally, Site B students described how several instructors convinced them of the value of group work by relating it to the work environment of professional engineers.

Differences in questions wording between Site A and Site B resulted in different insights. Site A questions and responses tended to focus on class sessions and to reinforce what is already published with respect to student resistance. The exact wording of the items also influenced the focus of student responses. Site B questions focused more broadly on learning and the entire experience of taking engineering courses, and as a result, identified additional types of resistance (outside of class time). Besides the question wording, the differences in student population at the two sites could also have resulted in different findings. For example, a similar version of the Site B questions were piloted with a sample of undergraduate summer research students from several institutions, and the responses to the question, "What sources would you say gave you the best idea of what to expect in college?" were fundamentally different. Students at Site B did not mention television and movies, but they supplied their own perceptions when we mentioned that others had. Instead of focusing on monotonous college lectures, Site B students contrasted the partying and dating aspects of college movies with the workload required of engineering majors. More direct comparison with a larger sample is simply needed to attribute the differences between the two data sets.

Implications for Instructors

Directly and indirectly, our student participants made a number of recommendations for engineering faculty members to reduce student resistance to nontraditional teaching approaches. Nontraditional approaches are more likely to be accepted by students if they are introduced at the beginning of the course, are well organized, and have a clear purpose. Students also noted that not all faculty are as skilled as they should be with facilitating various active learning pedagogies, and they suggested that faculty work with mentors or co-teach to gain experience. Students also explained that if they like an instructor, they will try to support his or her efforts (even if skeptical), but that if they dislike the instructor, they are more likely to view the nontraditional approach negatively.

Conclusion

Student focus groups provide an important student perspective on resistance and (as opposed to surveys and observations) help researchers understand the reasoning and attitudes underlying student behaviors. These focus groups helped identify additional types of resistance that take place outside of class sessions. However, they also highlighted an inherent weakness to asking participants to recall attitudes they held at an earlier time. By the point in the semester that focus groups were scheduled, the instructor at Site B had won her students over to the group problem-solving activities in the introductory materials science course. Students would not admit to or could not recall earlier skepticism, instead responding along the lines of "it all worked out in the end." The instructor, on the other hand, has vivid memories of students vocalizing their resistance to the approach at the beginning of the semester. This is consistent with research on memory and leads the researchers to note that focus groups have an optimal time-table for greatest confidence. Thus, as described in the literature, student focus groups are helpful in developing explanations and developing more structured research protocols, as we plan to do with classroom observations and surveys. In this case, student focus groups also help us to include the student perspective in research that has previously focused primarily on faculty experiences and attitudes.

Acknowledgements
This work was funded by the U.S. National Science Foundation through grants 1347417, 1347718, 1347482, and 1347580. We are grateful to the Dr. Shanna Daly and Kenyon Richardson for their integral involvement in conducting and analyzing the student focus groups at Site A.

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