2018 ASEE Annual Conference & Exposition
June 24–27, 2018
Salt Palace Convention Center
Salt Lake City, UT
Paper ID #21940

Impact of Prior Experiences on Future Participation in Active Learning

Mr. Robert Matthew DeMonbrun, University of Michigan

Matt DeMonbrun is a Ph.D. Candidate at the Center for the Study of Higher and Postsecondary Education (CSHPE) in the School of Education at the University of Michigan. His research interests include college student development theory, intergroup interactions, and teaching and learning practices and how they relate to student learning outcomes in engineering education.

Dr. Cynthia J. Finelli, University of Michigan

Dr. Cynthia Finelli is Associate Professor of Electrical Engineering and Computer Science, Associate Professor of Education, and Director and Graduate Chair for Engineering Education Research Programs at University of Michigan (U-M). Dr. Finelli is a fellow in the American Society of Engineering Education, a Deputy Editor of the Journal for Engineering Education, an Associate Editor of the IEEE Transactions on Education, and past chair of the Educational Research and Methods Division of ASEE. She founded the Center for Research on Learning and Teaching in Engineering at U-M in 2003 and served as its Director for 12 years. Prior to joining U-M, Dr. Finelli was the Richard L. Terrell Professor of Excellence in Teaching, founding director of the Center for Excellence in Teaching and Learning, and associate professor of electrical engineering at Kettering University.

Dr. Finelli's current research interests include student resistance to active learning, faculty adoption of evidence-based teaching practices, the use of technology and innovative pedagogies on student learning and success, and the impact of a flexible classroom space on faculty teaching and student learning. She also led a project to develop a taxonomy for the field of engineering education research, and she was part of a team that studied ethical decision-making in engineering students.

Impact of Prior Experiences on Future Participation in Active Learning

Introduction

Researchers have long emphasized the need to improve the quality of undergraduate teaching through the use of evidence-based instructional practices (EBIP), particularly for courses in the Science, Technology, Engineering, and Mathematics (STEM) fields. For example, the President's Council of Advisors on Science and Technology (PCAST) recommended in their report, Engage to excel: Producing one million additional college graduates with degrees in science, that undergraduate STEM education should "catalyze widespread adoption of empirically validated teaching practices" (p. ii). To this end, government agencies and higher education institutions have committed a vast amount of time and resources to developing and documenting the effectiveness of EBIP. More recently, several reports have focused on promoting this type of instructional change in the field of engineering. These reports, such as the American Society for Engineering Education's Creating a Culture for Scholarly and Systematic Innovation in Engineering Education (Jamieson & Lohmann, 2009) and Innovation with Impact (Jamieson & Lohmann, 2012), as well as the National Academy of Engineering's Barriers and Opportunities for 2-Year and 4-Year STEM Degrees (Malcom & Feder, 2016), have all presented the importance of EBIP in preparing future engineers for the workforce in the 21st century.

Despite research supporting the benefits of EBIP in the engineering field, the translation from research into practice (i.e., incorporating a diversity of practices in the classroom) has been slow (Friedrich, Sellers, & Burstyn, 2007; Handelsman et al., 2004; Hora, Ferrare, & Oleson, 2012; PCAST, 2012; Singer, Nielsen, & Schweingruber, 2012). In their investigation of the transition of RBIS to the engineering classroom, Cutler, Borrego, Prince, Henderson, and Froyd (2012) found that, out of 221 faculty surveyed, approximately 97% had knowledge about RBIS, but only 52% of these faculty were actively using it in their classrooms. Of the remaining 48%, 11% had not tried any of these practices in their classrooms, and the other 37% had tried these practices previously, but had abandoned them since their initial use. If the use of EBIP in the engineering classroom benefits students and faculty have knowledge of these strategies, why are faculty either choosing not to incorporate these practices in their curricula, or abandoning them altogether?

Research on faculty decisions about their teaching practices has identified a number of barriers to the adoption of these practices, including student resistance to active learning, questions about the efficacy of these practices, restrictions in course structure due of lack of time and/or content flexibility, and institutional policies and reward structures (Dancy & Henderson, 2010; Eddy, Converse, & Wenderoth, 2015; Felder & Brent, 1996; Finelli, Daly, & Richardson, 2014; Fraser et al., 2014; Froyd, Borrego, Cutler, Prince, & Henderson, 2013; Henderson & Dancy, 2007; Hora, 2012; Kiemer, Gröschner, Pehmer, & Seidel, 2015; Prince, Borrego, Cutler, Henderson, & Froyd, 2013; Seidel & Tanner, 2013). Concern about student resistance, whether evidenced through formal course evaluations or expressed in other ways, has an alarming effect on instructors' willingness to adopt EBIP. There also remains a question regarding how students' prior experiences with different types of instruction might impact their responses to the same activities in the future. In other words, can student response to an activity change between semesters, and if so, how does their response in prior courses differ from that in future courses? This paper examines students' responses to different types of instruction in the engineering classroom – including those types used most often in engineering courses – and investigates how their responses may differ across courses between semesters.

Methodology

This study investigates student response in five engineering specialties at a large public university in the Midwest. The engineering specialties include: electrical engineering, computer science engineering, chemical engineering, mechanical engineering, and biomedical engineering. From the course offerings, one course section was randomly selected from each of the engineering disciplines. The selection pool included sophomore-level courses (i.e., 200-level courses) with minimum enrollments of at least 50 students. While these courses differ by discipline, all are similar in that they are lecture sections of the course (i.e., no laboratory or discussion sections), they are one of the first courses taken in the disciplinary sequence (i.e., a sophomore-level gateway course), they typically enroll only students of sophomore status (after students have declared their major), and they enroll a large number of students. Each section had enrollments of between 73 and 148 students, with an average enrollment of 108 students. The total population sampled was 539 students. No students were enrolled in more than one course during the survey administration.

I employed a series of two student surveys, which were based on the Student Response to Instructional Practices instrument (StRIP instrument; DeMonbrun et al., 2017). Survey 1 was administered between the fifth and seventh weeks of Winter 2017. This timing allowed students to gain an understanding of the types of instruction most frequently used in the course. Additionally, prior experience items asked them to draw upon experiences in an engineering course in the previous academic semester. Survey 2 was administered between the thirteenth and fifteenth weeks in the course, immediately prior to final examinations. This allowed students to accurately depict their responses to each type of instruction frequently experienced in the current course as well as their general evaluation of the course (evaluation construct items).

In Survey 1, students were asked to consider the engineering course they took in the previous semester that was the most relevant to their current course and to indicate their prior experience with four of the most commonly used types of instruction in engineering course. These types of instruction include: "listen to the instructor lecture during class," "answer questions posed by instructor during class," "brainstorm different possible solutions to a given problem," and "discuss concepts with classmates during class." If a student had been exposed to this type of instruction in the prior course, s/he was also asked how s/he typically responded to it using four classroom engagement constructs of value, positivity, participation, and distraction (Table 1; DeMonbrun et al., 2017; Fredricks et al., 2004). In other words, all students were asked to answer each of the 13 response items for each of these four types of instruction (Table 1). In Survey 2, students were asked about their response to each of these same types of instruction as indicated in Survey 1, but it differs in asking these items in regards to the course in the current research study. The sample used in the results section of this study included 242 students who completed both Survey 1 and 2.

Table 1
"Students' Responses to Instruction" Items

In your prior course, when the instructor asked you to participate in this type of instruction, how often did you react in the following ways?

1. Almost never (<10% of the time); 2. Seldom (~30% of the time); 3. Sometimes (~50% of the time); 4. Often (~70% of the time); 5. Very often (>90% of the time)

Value	1. I felt the effort it took to do the activities was worthwhile. 2. I saw the value in the activities. 3. I felt the time used for the activities was beneficial.
Positivity	4. I disliked the activities. (R) 5. I felt positively towards the instructor because of the activities. 6. I enjoyed the activities. 7. I complained to other students about the activities. (R)
Participation	8. I tried my hardest to do a good job with the activities. 9. I did not actually participate in the activities. (R) 10. I gave the activities minimal effort. (R) 11. I distracted my peers during the activities. (R) 12. I pretended to participate in the activities. (R) 13. I surfed the internet, checked social media, or did something else instead of doing the activities. (R)

(R) These items were reverse-coded.

Results

The mean scores of each of factors from Surveys 1 and 2 are provided in Table 2 for both prior course experiences (Survey 1) and their currently enrolled course (Survey 2). I also compared the response scores between their prior and current courses using a dependent t-test for paired samples. When students were asked to "listen to the instructor lecture during class," they expressed value towards this type of instruction closer to *often* (mean = 3.78) in prior courses, but only *sometimes* in the current course (mean = 3.25). This represented a significant decrease in their scores from Survey 1 to Survey 2 ($p<0.001$). This finding was similar to students' participation in the course, as scores significantly decreased from 3.20 to 3.05 ($p<0.05$). In contrast, students' positive feelings towards this type of instruction and the instructor significantly increased between Surveys 1 and 2 from 2.83 to 3.02 ($p<0.01$).

For “answering questions posed by instructor during class,” students reported similar decreases in value between Surveys 1 and 2 from 3.73 to 3.16 ($p<0.001$), and similar increases in positivity from 2.66 to 3.20 ($p<0.001$) for this type of instruction. Responses differed, however, in that students reported greater participation levels from 3.08 to 3.23 ($p<0.01$). Similar decreases and increases were reported for “brainstorming different possible solutions to a given problem,” as students expressed a decrease in value (3.82 to 3.13; $p<0.001$) and an increase in positivity (2.78 to 3.02; $p<0.001$) and participation (3.10 to 3.24; $p<0.01$). Finally, for “discuss concepts with classmates during class,” students reported an increase in both value (2.01 to 2.17; $p<0.05$) and positivity (2.73 to 3.17; $p<0.001$). Note that for value, however, despite the increase in responses from Survey 1 to Survey 2, the mean scores remained nearly one point below the other three types of instruction.

Table 2
Mean Scores for Student Response to Each Type of Instruction
in Prior and Current Courses (n=242)

Type of Instruction	Listen to Lecture			Answer Q’s Posed			Brainstorm Diff. Sol.			Discuss Concepts		
Student Response	Prior	Current		Prior	Current		Prior	Current		Prior	Current	
Value	3.78	3.25	***	3.73	3.16	***	3.82	3.13	***	2.01	2.17	*
Positivity	2.83	3.02	**	2.66	3.20	***	2.78	3.02	***	2.73	3.17	***
Participation	3.20	3.05	*	3.08	3.23	**	3.10	3.24	**	3.23	3.20	

Note: Significance values are for paired sample t-test of the difference between prior and current values
* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Discussion

There are several takeaways from this research study. First, these results suggest that student participation in EBIP is context dependent, and it varies by the type of instruction used in the classroom. For example, students reported participating more often in activities that included “answering questions posed by instructor during class”, “brainstorming different possible solutions to a given problem”, and “discussing concepts with classmates during class.” Interestingly, students reported participating in “listening to the instructor lecture during class” less often between Surveys 1 and 2, despite this often being the most predominant type of instruction that students encountered in the engineering classroom (Nguyen et al., 2017). Despite differing levels of participation, student still reported more positive feelings about the type of instruction or instructor between Surveys 1 and 2 for all four EBIP, while reports of value were mixed with significant decreases “listening to the instructor lecture during class,” “answering questions posed by instructor during class,” and “brainstorming different possible solutions to a given problem,” while value score increased for “discussing concepts with classmates during class.”

Second, despite the significant differences in scores between Surveys 1 and 2, most of the mean response scores for each of the four types of instruction remained between 2.5 and 3.5, suggesting that while there are differences in how students respond to different types of instruction (and the same type of instruction in prior and current courses), the differences are often negligible. The one exception is the value response score for “discussing concepts with classmates during class.” Both the Survey 1 and Survey 2 scores were around an entire point lower that each of the other three types of instruction. Of course, this type of instruction is the only one that cites working with other classmates during an activity, which may suggest that students struggle to see the value in group work-oriented types of activities when compared to other activities that may experience in the classroom.

Although EBIP have long been recognized as being beneficial for student learning (Johnson et al., 1991), the nature with which students might respond to such practices has not been as thoroughly investigated. This study represents another step in better understanding student response to types of instruction in the engineering classroom, particularly with regards to how these responses may differ across semesters; however, these are the findings for one semester of courses at one institution, and thus, we encourage future research studies to investigate these responses further.

References

Brown, A., & Campione, J. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice (pp. 229–270). Cambridge, MA: MIT Press.

Cutler, S., Borrego, M., Henderson, C., Prince, M., & Froyd, J. (2012*). A Comparison of Electrical, Computer, and Chemical Engineering Faculty's Progression through the Innovation-Decision Process.* Paper presented at the Frontiers in Education Conference, Seattle WA.

Dancy, M. H., & Henderson, C. (2010). Pedagogical practices and instructional change of physics faculty. *American Journal of Physics, 78*, 1056–1063.

DeMonbrun, M., Finelli, C. J., Borrego, M., Shekhar, P., Prince, M., Henderson, C, & Waters, C. (2017). Creating an Instrument to Measure Student Response to Instructional Practices. *Journal of Engineering Education, 106*(2), 273-298.

Eddy, S. L., Converse, M., & Wenderoth, M. P. (2015). PORTAAL: A classroom observation tool assessing evidence-based teaching practices for active learning in large science, technology, engineering, and mathematics classes. *CBE-Life Sciences Education*, *14*(2), ar23.

Felder, R. M., & Brent, R. (1996). Navigating the bumpy road to student-centered instruction. *College teaching*, *44*(2), 43-47.

Finelli, C. J., Daly, S. R., & Richardson, K. M. (2014). Bridging the research-to-practice gap: Designing an institutional change plan using local evidence. *Journal of Engineering Education, 103*(2), 331-361. http://dx.doi.org/10.1002/jee.20042

Fraser, J. M., Timan, A. L., Miller, K., Dowd, J. E., Tucker, L., & Mazur, E. (2014). Teaching and physics education research: Bridging the gap. *Reports on Progress in Physics*, *77*(3), 032401.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of educational research*, *74*(1), 59-109.

Friedrich, K., Sellers, S., & Burstyn, J. (2007). Thawing the chilly climate: Inclusive teaching resources for science, technology, engineering, and math. *To Improve the Academy: Resources for Faculty, Instructional, and Organizational Development, 26*, 133-144.

Froyd, J., Borrego, M., Cutler, S., Prince, M., & Henderson, C. (2013). Estimates of use of research-based instructional strategies in core electrical or computer engineering courses. *IEEE Transactions on Education, 56*(4), 393-399.

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Stewart, J., Tilghman, S. M., & Wood, W. B. (2004). Scientific teaching. *Science, 304*(5670), 521-522.

Henderson, C., & Dancy, M. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics - Physics Education Research, 3*(2), 020102-020101 to 020102-020114.

Hora, M. T. (2012). Organizational factors and instructional decision-making: A cognitive perspective. *Review of Higher Education, 35*(2), 207–235.

Hora, M. T., Ferrare, J., & Oleson, A. (2012). Findings from classroom observations of 58 math and science faculty. Madison, WI: University of Wisconsin-Madison, Wisconsin Center for Education Research.

Jamieson, L. H., & Lohmann, J. R. (Eds.). (2009). *Creating a culture for scholarly and systematic innovation in engineering education: Ensuring U.S. engineering has the right people with the right talent for a global society.* Washington, DC: American Society for Engineering Education. https://www.asee.org/memberresources/reports/CCSSIE/CCSSIEE_Phase1Report_June2009.pdf

Jamieson, L. H., & Lohmann, J. R. (Eds.). (2012). *Innovation with impact: Creating a culture for scholarly and systematic innovation in engineering education.* Washington, DC: American Society for Engineering Education. https://www.asee.org/memberresources/reports/Innovation-with-Impact/Innovation-With-Impact-Report.pdf.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). *Active learning: Cooperation in the college classroom.* Edina, MN: Interaction Book Co.

Kiemer, K., Gröschner, A., Pehmer, A. K., & Seidel, T. (2015). Effects of a classroom discourse intervention on teachers' practice and students' motivation to learn mathematics and science. *Learning and instruction*, *35*, 94-103.

Malcom, S., & Feder, M. (Eds.). (2016). *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways*. Washington, D.C.: National Academies Press.

Nguyen, K. A., DeMonbrun, R. M., Borrego, M. J., Prince, M. J., Husman, J., Finelli, C. J., ... & Waters, C. (2017). The Variation of Nontraditional Teaching Methods Across 17 Undergraduate Engineering Classrooms. Proceedings of the ASEE Annual Conference & Exposition, Columbus, Ohio.

President's Council of Advisors on Science and Technology (PCAST). (2012). *Report to the president: Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics.* Washington, DC: Executive Office of the President.

Prince, M. J., Borrego, M., Cutler, S., Henderson, C., & Froyd, J. E. (2013). Use of research-based instructional strategies in core chemical engineering courses. *Chemical Engineering Education, 47*(1), 27–37.

Seidel, S. B., & Tanner, K. D. (2013). "What if students revolt?"—considering student resistance: Origins, options, and opportunities for investigation. *CBE-Life Sciences Education*, *12*(4), 586-595.

Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (Eds.). (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. Washington, D.C.: National Academies Press.