Extended Abstract - Students' Expectations and Responses to Active Learning in Undergraduate Engineering Courses

Kevin Nguyen, Prateek Shekhar, Jenefer Husman, Maura Borrego, Michael Prince, Cynthia Finelli, Cindy Waters, Robert Matthew DeMonbrun, Charles Henderson
kevin.a.nguyen@utexas.edu, pshekshar@utexas.edu, jenefer.husman@asu.edu, maura.borrego@austin.utexas.edu, prince@bucknell.edu, cfinelli@umich.edu, kwaters@ncat.edu, mdemonbr@umich.edu, charles.henderson@wmich.edu

Abstract **- As engineering instructors adopt new teaching strategies, many instructors face anxiety about how their students will respond to their new in-class instructional activities. The fear of student resistance to their new teaching strategy has been identified as a barrier by engineering instructors' adoption and continued use of active learning. This research project focuses on examining students' classroom expectations to explain student resistance to active learning in engineering classrooms. We have developed a survey instrument to study how students respond to in-class instructional practices (StRIP). Descriptive statistics, correlations, and regression models are used to draw conclusions about how students' expectations and perceived occurrence of in-class activities in the course have an effect on how students respond. The population surveyed involved four active learning courses from three different four year public universities (227 total students). Results suggest that there are three significant predictors of student response: expectations of passive instructions two weeks into the course, the perceived occurrence of group work, and the initial expectations of active instruction.**

Index Terms - Active Learning, Resistance, Expectations

BACKGROUND

Non-traditional methods of instruction such as active learning are effective in improving student learning when compared to lecture-based instruction [1, 2]. The benefits of active learning have been extensively disseminated through engineering education conferences, journals, and workshops. As engineering instructors adopt active learning, many instructors face anxiety about how their students will respond to their new in-class instructional activities. The fear of student resistance or students' negative response to active learning based teaching methods has been cited as a critical factor contributing to engineering instructors' slow adoption and discontinuation of active learning [3, 4].

Active learning based instruction may lead to student resistance because it often requires more work from student during class when compared to traditional lecture based instruction [5]. Although researchers and faculty development experts have recommended strategies to reduce student resistance [6, 7], minimal research has been conducted to study student resistance to active learning in engineering classrooms. In order to increase the adoption of active learning in engineering courses, it is important to not only disseminate information about research based teaching methods but address faculty reported concerns through further inquiry in the area. Using expectancy violation theory as our guiding lens, this research project focuses on examining students' classroom expectations to explain student resistance to active learning in engineering classrooms.

Expectancy violation theory provides one explanation for the occurrence of student resistance to active learning [8, 9]. The theory posits that students respond negatively to active learning because their expectations about classroom instruction are violated by the implementation of active learning based instruction. In other words, students who expect to engage passively (e.g. listening and note taking) resist when they are asked to engage in different activities during class time. Additional participation and effort is required from students in active learning based instruction which often conflicts with their classroom expectations.

Gaffney, et al. [8] examined student expectations in a large active learning based introductory physics course. The researchers argued that students often orient their expectations based on their classroom experiences. In other words, students expecting traditional lecture based instruction may align their expectations with the actual implemented instruction after they experience active learning in a course. Advocating the importance of understanding both students' initial expectations and their oriented expectations after enrolling in an active learning course, the research design involved administering of student surveys at the beginning, after two weeks, and end of the semester.

RESEARCH DESIGN AND SURVEY INSTRUMENT

Following a similar approach [1], in this study, we examine the relationship between student response to active learning and their expectations about classroom instruction at the beginning and after two weeks of the semester. In addition, we study the relationship between student response and the

implemented classroom instruction reported by the students at the end of the semester.

In order to quantitatively assess students' expectations and responses to active learning, we developed the Student Responses to Instructional Practices (StRIP) Survey instrument. The instrument is designed to be administered three times during a semester. Due to the large number of items on the StRIP Survey, the StRIP Survey is collapsed into factors or sub constructs using both exploratory and confirmatory factor analysis. All of the survey items in this analysis use a Likert scale from 1 to 5, as students are asked the expected occurrence of each item with 1 being never and 5 being very often.

Student response to active learning is characterized using five sub constructs or factors – Distraction, Participation, Value, Emotion and Evaluation (Table I). Distraction and participation category examines students' in-class behavior during the active learning sessions. The participation items ask students how often they engaged in the activities during the semester. The distraction items ask students to report their in-class resistance [10]. For the value and emotion items, students report how often they felt the activities were beneficial to their learning and how often they enjoyed engaging in the activities. Lastly, the evaluation category gathers students' overall response to the course and the instructor.

On the other hand, the classroom instruction items cover the various types of instruction that might occur in a classroom. The items are categorized into – Passive Traditional Lecture, Active Learning Lecture, Group Work and Student led activities (Table I). While passive traditional lecture category covers instruction such as note taking and listening to the instructor. The other three categories focus on different characteristics of active learning. Active learning lecture involves answering questions and problems posed by the instructor during class. Group work category caters to activities requiring students to engage in groups in both in-class activities and projects outside class. Lastly, student led activities targets active learning types such as self-directed and problem based learning, which require students to take responsibility of their own learning while working on open ended problems.

RESEARCH QUESTIONS

Using an informed research design and sub constructs developed from our StRIP Survey instrument, we aim to explore the following questions:

- How does students' expectations at the beginning and two weeks into the semester predict how students respond to an active learning undergraduate engineering classroom?
- How does the students' perceived occurrence of in-class activities at the end of the course predict how students respond to an active learning undergraduate engineering classroom?

TABLE I
SURVEY FACTORS AND RESPECTIVE SURVEY ITEMS

		Survey Items
Classroom Instruction	Passive Traditional Lecture	• Listen to the instructor lecture during class. • Get most of the information needed to solve the homework directly from the instructor. • Watch the instructor demonstrate how to solve problems.
	Basic Active Learning Lecture	• Solve problems individually during class. • Answer questions posed by the instructor during class. • Ask the instructor questions during class.
	Group Work	• Work in assigned groups to complete homework or other projects. • Study course content with classmates outside of class. • Discuss concepts with classmates during class. • Solve problems in a group during class. • Do hands-on group activities during class. • Be graded on my class participation.
	Constructive Activities Open Ended Problem Solving	• Brainstorm different possible solutions to a given problem. • Find additional information not provided by the instructor to complete assignments. • Make individual presentations to the class. • Assume responsibility for learning material on my own. • Make and justify assumptions when not enough information is provided. • Solve problems that have more than one correct answer. • Take initiative for identifying what I need to know.
Student Response	Distraction	• I talked with classmates about other topics besides the activity. • I distracted my peers during the activity • I surfed the internet, checked social media, or did something else instead of doing the activity
	Participation	• I participated actively (or attempted to) • I tried my hardest to do a good job
	Value	• I felt the time used for the activity was beneficial • I saw the value in the activity • I felt the effort it took to do the activity was worthwhile
	Emotion	• I felt positively towards the instructor/class • I felt the instructor had my best interests in mind • I enjoyed the activity
	Evaluation	• Overall, this was an excellent course • Overall, the instructor was an excellent teacher.

RESEARCH POPULATION AND QUANTITATIVE METHODS

Four undergraduate engineering active learning courses were sampled from three different four year universities. 227 total students were surveyed.

In order to answer our research questions, we used a combination of different quantitative methods. First, descriptive statistics were used to show what students expectations were at the beginning and two weeks into the course as well as their perceived occurrence of in-class activities. Second, the data were log transformed and centered in order to reduce violations of normality and to explore interaction effects. Next, bivariate Pearson correlations with significance testing at the 0.05 level were run to determine whether the classroom instruction factors were significantly correlated with the student response factors. Finally, a linear regression analysis was used to determine if classroom instruction factors were significant predictors of the response factors.

RESULTS

Students reported their expectations of classroom instruction activities at the beginning (pre) and two weeks into the semester. Students also report the perceived occurrence of classroom instruction activities at the end of the semester (post). The average of students' expectations of classroom instruction at the three different times are listed below in Figure 1. The error bars represent the standard deviation from the mean score.

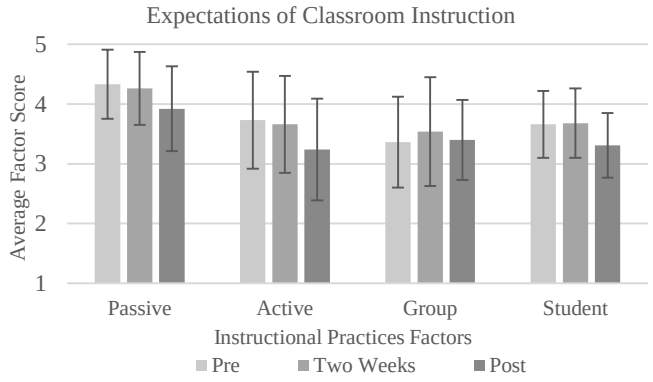

FIGURE 1
AVERAGE STUDENTS EXPECTATIONS OF CLASSROOM INSTRUCTION

For passive traditional lecture (passive), active learning lecture (active), and student led activities (student) instructional factors, students began with higher average expectations of these classroom instruction activities and ended up with less of what was actually performed in the classroom. The group work (group) instructional factor started with lower expectations, had higher expectations two weeks into the course, and ended with less at the end of the course. Overall, these instructional factors showed that their expectations of instructional activities were often higher than what actually occurred in the course, and students' expectations were violated, but only in the way that students expected more than what they actually received.

Students' responses to the active learning classroom were surveyed in the final post survey. The average of students' responses or types of responses are provided in Figure 2.

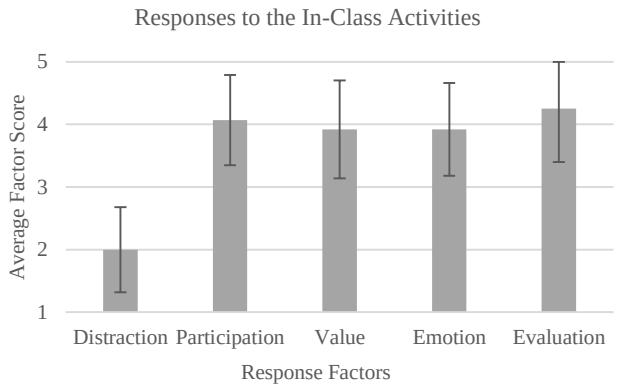

FIGURE 2
AVERAGE STUDENTS' RESPONSES TO THE IN-CLASS ACTIVITIES

Overall, we see that students responded very positively to the in-class activities. Distraction, which accounts for negative responses, was the only type of response that scored below an average of three. We can see that students on average evaluated the course highly, and the students often participated, valued, and felt emotionally positive engaged with the in-class activities.

Bivariate Pearson correlation with significant testing depicted that only some of the expectations and perceived occurrence of in-class activities in the classroom were significantly correlated with the response factors. Table II lists the significant correlations between a classroom instruction factor and a student response factors at the three different survey times. Group and passive classroom instruction factors correlated with many of the response variables at different times. All correlations are in the positive direction unless specified otherwise.

TABLE II
SIGNIFICANT CORRELATIONS
BETWEEN CLASSROOM INSTRUCTION FACTORS
AND RESPONSE FACTORS BY TIME

Time	Classroom Instruction Factor			
	Passive	Active	Student	Group
Pre		Participation Evaluation*		Participation
Two Weeks	Distraction* Participation Value	Value	Value Emotion	Value Emotion Evaluation
Post	Value Emotion Evaluation			Participation Value Emotion Evaluation

* - Negative Correlation

Using the significant bicorrelations as a guide, regression were run to see if the classroom instruction factors were significant predictors of our student response factors.

The goal was then to build a multiple regression model for each of the response factors.

Distraction was only significantly correlated with the passive instruction factor two weeks into the course (Table II). This bivariate correlation is effectively similar to a single predictor regression model, and we can say that students' expectations of passive instruction (two weeks) is a significant negative predictor of distraction.

Participation was significantly correlated with passive (two weeks), active (pre), group (pre), and group (post) (Table II). Running a linear regression model with these multiple predictors resulted in only passive (two weeks) and group (post) as significant predictors of participation. Both were positively correlated with participation. In other words, as students expect more passive instruction and actually receive group work, students are more likely to participate on an average.

Value had significant correlations with passive (two weeks), passive (post), active (two weeks), student (two weeks), group (two weeks), and group (post) (Table II). Upon running a multiple linear regression with these predictors, again only expectations of passive instruction two weeks into the course and the amount of group work at the end of the course were significantly correlated with the response factor. Both predictors were positively correlated with value.

From the correlation analysis, emotion was found to be significantly correlated with passive (post), student (two weeks), group (two weeks), and group (post) (Table II). In a combined multiple linear regression only group (post) was a significant positive predictor of emotion.

Finally, evaluation was significantly correlated with passive (pre), active (pre), group (two weeks), and group (post). In a multiple linear regression, only active (pre) and group (post) were significant predictors of evaluation. Expectations of active instruction at the beginning of the class were a significant predictor of evaluation in the negative direction, and the perceived occurrence of group activities were a significant predictor of evaluation in the positive direction.

DISCUSSION

The preliminary results of this analysis inform how students' expectations and the perceived occurrence of in-class activities predict how students respond to active learning instruction. The expectations of passive instruction two weeks into the course was a significant predictor of distraction, participation, and value types of responses. By two weeks into the course, students may expect a continuation of the same amount of lecturing for the rest of the course, and how much they expect of this is positively related to participation and value and negatively related to distraction. This finding supports that passive instruction does have a time and place in active learning classrooms, and students respond favorably to it.

The perceived occurrence of group work at the end of the course was a significant positive predictor of participation, value, emotion, and evaluation. The more group work students received, the more positively they responded to doing in-class activities in the classroom. This is an important finding to support that students are willing to perform group work in the classroom. We imagined that undergraduate engineering students would strongly resist group activities, but this current data set and analysis actually points to students responding very favorably to group work in their classrooms.

Expectations of active instruction at the beginning of the course was a significant negative predictor of evaluation. Fittingly, as students expect a more active classroom, the less they think they will like the course. This supports the idea that many students originally do not think they would like a nontraditional classroom.

The quantitative methods used in this analysis can be seen as a step by step process of distilling a large amount of survey data down to statistically significant findings. The correlation analysis signaled that there were various significant correlations between the instruction factors and the response factors, but the multiple linear regression models showed only three of instruction factors as significant predictors of the student response factors. The lack of more significant predictors of student response may result from the effects of multicollinearity, or the strong correlations between the predictor variables, and this reduces the chance that all predictors in a multiple regression model will be statistically significant.

CONCLUSION AND FUTURE WORK

Students come into their courses with varying expectations of classroom instruction. As the course goes on, their expectations can change, and what classroom activities get implemented throughout the course can also change. Surveying for all these expectations with the StRIP Survey instrument allowed us to begin observing how students' expectations relate to their responses to active learning. This analysis shows us that there may be some significant relationships between classroom instruction and student response. The perceived occurrence of group work, the expectations of passive traditional lecture two weeks into the course, and the initial expectations of active learning lecture can significantly predict how students respond to active learning in the classrooms. Thus, group work and passive instruction positively influence students' response in active learning based undergraduate engineering classroom. Future work in this project will aim to address the loss of significant predictors in multiple linear regression, as we may move on to other forms of quantitative analysis such as path analysis or structural equation modeling. Further data analysis will also be supported with more active learning courses sampled.

ACKNOWLEDGMENT

This project is funded by the U.S. National Science Foundation through grant numbers 1347417, 1347482, 1347580, 1347718, and 1500309. The opinions are those of the authors and do not necessarily represent the National Science Foundation. The authors would like to thank the

instructors and students who agreed to be part of the pilot study, as well as project advisory board members.

REFERENCES

[1] M. Prince, "Does Active Learning Work? A Review of the Research," *Journal of Engineering Education*, vol. 93, pp. 223-231, 2004.
[2] D. W. Johnson, R. T. Johnson, and K. A. Smith, "Active learning: Cooperation in the college classroom," ed. Edina, MN: Interaction Book Co., 1991.
[3] M. Prince, M. Borrego, C. Henderson, S. Cutler, and J. Froyd, "Use of Research-Based Instructional Strategies in Core Chemical Enginering Courses," *Chemical Engineering Education*, 2014.
[4] Finelli, C. J., Daly, S. R., & Richardson, K. M, "Bridging the research-to-practice gap: Designing an institutional change plan using local evidence," *Journal of Engineering Education*, 103(2), 331-361, 2014.
[5] G. S. Åkerlind and A. C. Trevitt, "Enhancing Self-Directed Learning through Educational Technology: When Students Resist the Change," *Innovations in Education and Training International*, vol. 36, pp. 96-105, 1999.
[6] M. Prince and R. M. Felder, "The many faces of inductive teaching and learning," *Journal of College Science Teaching*, vol. 36, p. 14, 2007.
[7] R. M. Felder, "Hang in there! Dealing with student resistance to learner-centered teaching," *Chemical Engineering Education*, vol. 43, pp. 131-132, 2011.
[8] J. D. H. Gaffney, A. L. H. Gaffney, and R. J. Beichner, "Do they see it coming? Using expectancy violation to gauge the success of pedagogical reforms," *Physical Review Special Topics - Physics Education Research*, vol. 6, 2010.
[9] C. D. Koermer and J. L. Petelle, "Expectancy Violation and Student Rating of Instruction," *Communication Quarterly*, vol. 39, pp. 341-350, 1991.
[10] M. Weimer, *Learner-Centered Teaching: Five Key Changes to Practice*. San Francisco: Jossey-Bass, 2013.

AUTHOR INFORMATION

Kevin Nguyen, Graduate Research Assistant, Department of STEM Education, University of Texas at Austin, kevin.a.nguyen@utexas.edu

Prateek Shekhar, Graduate Research Assistant, Department of Mechanical Engineering, University of Texas at Austin, pshekhar@utexas.edu

Jenfer Husman, Associate Professor, School of Social and Family Dynamics, College of Liberal Arts and Sciences, Arizona State University, jenefer.husman@asu.edu

Maura Borrego, Associate Professor, Department of Mechanical Engineering, Department of Curriculum & Instruction, University of Texas at Austin, maura.borrego@austin.utexas.edu

Michael Prince, Professor, Department of Chemical Engineering, Bucknell Unversity, prince@bucknell.edu

Cynthia Finelli, Associate Professor, Department of Electrical Engineering & Computer Science, University of Michigan, cfinelli@umich.edu

Cindy Waters, Assistant Professor, Department Mechanical Engineering, North Carolina Agricultural & Technical State University, kwaters@ncat.edu

Robert Matthew DeMonbrun, Graduate Research Assistant, School of Education, University of Michigan, mdemonbr@umich.edu

Charles Henderson, Professor,
Department of Physics, Western Michigan University, charles.henderson@wmich.edu