Students' Expectations, Types of Instruction, and Instructor Strategies Predicting Student Response to Active Learning

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Abstract

Engineering instructors' adoption of active learning has been slow, despite significant evidence supporting its efficacy. A common instructor concern is that students will respond negatively. This study measures the relationship between student response to instruction and 1) students' expectations for types of instruction, 2) students' experiences of different types of instruction, and 3) instructor strategies for using in-class activities. Student Response to Instructional Practices (StRIP) survey data from 179 students at three U.S. institutions were analyzed using hierarchical linear regression modeling. Significant predictors in the final models of student response were student expectations of active learning lecture and passive lecture, experiences of group based activities, and instructor strategies for explaining and facilitating active learning. These empirical results support recommendations in prior literature about best practices for reducing student resistance and demonstrate that instructors have great power to influence student reactions to active learning and ultimately reduce student resistance. There was no evidence in this data set to support the common concern that instructor or course evaluations are negatively affected by adopting active learning strategies.

Keywords: active learning; instructional methods; engagement; regression modeling

1. Introduction, Rationale, and Research Questions

Non-traditional methods of instruction such as active learning are effective in improving student learning when compared to lecture-based instruction [1, 2]. In this paper, active learning is defined as teaching methods that incorporate student engagement in the classroom. The benefits of active learning have been extensively disseminated through engineering education conferences (e.g., European Society for Engineering Education, American Society for Engineering Education and Frontiers in Education), journals (e.g., *International Journal of Engineering Education, Journal of Engineering Education,* and *European Journal of Engineering Education*), and workshops (e.g., National Effective Teaching Institute). As engineering instructors consider adopting active learning, many 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 has been cited as a critical factor contributing to engineering instructors' slow adoption and discontinuation of active learning [3, 4]. Although researchers and faculty development experts have recommended strategies to reduce student resistance [5, 6], 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 using active learning but also address instructors' reported concerns through further inquiry in the area.

Expectancy violation theory provides one explanation for the occurrence of student resistance to active learning [7, 8]. The theory posits that students respond negatively to active learning because they expect passive lecture instruction but receive active learning. 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. Gaffney et al. [7] examined students' expectations at the beginning and a few weeks later in a large, active learning based, introductory physics course. They suggested the importance of understanding both students' expectations at the beginning of the course and a few weeks into the course because any violation of these expectations could result in student resistance to active learning.

We created the Student Response to Instructional Practices (StRIP) survey to measure students' expectations of active learning and other types of instruction [9]. The StRIP survey also measures students' experiences of types of instruction, instructor strategies for using in-class activities, and student response to instruction. We created the StRIP survey to measure more than active learning and student resistance to active learning in order to explore the different modalities of student response to instruction as well as the effects of different types of instruction. Using the StRIP survey, we hypothesize that students' expectations of types of instruction relate to student response to instruction. We also hypothesize that the students' experiences of types of instruction relates to how students respond. Finally, we hypothesize that instructor strategies for using in-class activities also relate to how students will respond to active learning. By exploring these relationships, we hope to build a model of student response to instruction in active learning classrooms. To summarize, we ask the following research questions:

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- What, if any, is the relationship between students' response to instruction, and the students' expectations of different types of instruction?
- What, if any, is the relationship between students' response to instruction, and the students' reported frequency of different types of instruction?
- What, if any, is the relationship between students' response to instruction, and instructor strategies for using in-class activities?
- How can these relationships be used to significantly predict student responses to instruction?

Answering these questions will allow us to take actionable steps toward understanding and reducing student resistance to active learning and ultimately increasing adoption of such practices. We begin by reviewing literature on student response to active learning in STEM (science, technology, engineering, and mathematics) classrooms and strategies for implementing active learning. This is followed by an explanation of this study's research design and a more in-depth overview of the StRIP survey instrument. Results from this study are then provided, which is followed by a discussion of implications of the results for teaching and active learning. Finally, a conclusion and a discussion of future work is provided.

2. Literature Review on Student Response to Active Learning

2.1 Positive Responses to Active Learning

Several studies show a primarily positive student reaction to a range of active learning techniques [10-17]. For example, Arce [10] examined student response to an active learning technique that emphasized guided discussion of concept questions. He found that the majority of students in three subsequent offerings of an undergraduate heat transfer course (100%, 88% and 79%) agreed that the active learning approach was effective for promoting learning. Similarly, Oakley et al. [15] reported that participation in student team activities correlated positively with student reports that the course objectives had been met. In courses using teamwork as a type of active learning, results showed that students' perception of the course and the instructor increased with team experience satisfaction, the level of instructor guidance on teamwork, the absence of slackers, and the provision of measures to deal with slackers [15]. These results suggest that assigning work to student teams can lead to learning benefits and student satisfaction, provided that the instructor pays attention to how the teams and the assignments are facilitated [15]. Like any teaching method, active learning can be implemented well or poorly, and it does not inevitably result in negative student responses.

2.2 Negative and Mixed Responses to Active Learning

Several other studies have reported student resistance to active learning [6, 18-22]. Lake [21] examined the effect of active learning on student perceptions of a physiology course. Despite success in using active learning to achieve higher gains in student learning, Lake reports that the students' perceptions of course effectiveness were lower in the active learning courses than in the lecture course. Similarly, Yadav et al. [22] examined the impact of problem based learning on students in an undergraduate engineering course. They found that students reported that they learned less in the problem based learning environment even though objective measures of learning showed that they in fact learned more.

Other studies show more mixed results of how students respond to active learning methods [23-30]. For example, Hall et al. [26] report a range of student responses to active learning, with some students reporting it to be more effective than traditional instruction and others considering the activities to be "irrelevant fluff". Another study examined 492 students' mixed perceptions of active learning in undergraduate science lectures [30]. Thirty percent of survey respondents perceived active learning as unimportant or slightly important to positively influencing their academic performance, while another 30% perceived it as somewhat important, and about 40% perceived it as important or very important. Similarly, Wilke [29] examined the effect of introducing active learning into an undergraduate physiology course on several affective outcomes. He found that some measures (e.g., self-efficacy) showed improvements with active learning, while many other affective outcomes showed no statistically significant difference between active learning and traditional instruction. This observation is also similar to the results of students in basic biology courses, as Goodwin et al. [25] reported that students in courses with half lecture and half small-group discussions felt that they had learned less compared with students in previous lecture-only courses, despite performing similarly or better in subsequent biology courses compared to students in more conventional lecture-style courses. Students appear to have various responses to active learning courses, and more work needs to be done on exploring how and why they respond in different ways. However, some work has been done on suggesting ways to reduce negative student response to active learning.

2.3 Instructor Strategies to Reduce Negative Student Response

Minimal empirical research has examined the effectiveness of instructor strategies to mitigate student resistance, yet several authors have offered suggestions for instructors to reduce student resistance to active learning [6, 19, 21, 31, 32]. These suggestions have been either based on authors' experiences [6, 19] or have been part of reflective discussions in their articles examining student outcomes [21, 22]. For example, in a study examining the influence of problem-based learning on student learning in an electrical engineering course, Yadav et al. [22] recommended acknowledging the challenges of the new teaching approach, soliciting students' feedback, and providing students with support and scaffolding. Researchers have also suggested that students' expectations can change during the semester and instructors can reduce resistance by better aligning students' expectations with the implemented instructional practices [7]. For example, clearly explaining expectations about classroom engagement [31] and the purpose behind the use of active learning [29] may better prepare students for active learning. The current study provides much-needed empirical evidence of the effectiveness of these suggested strategies, as some of these strategies are included in the instructor strategies for using in-class activities section of the StRIP survey instrument.

3. Survey Instrument and Quantitative Methods

3.1 StRIP Survey Instrument Measures

We developed, validated, and piloted the StRIP survey prior to this administration of the instrument. Survey development and validation included classroom observations [33], expert review, cognitive interviews, and testing in traditional and active lecture based classrooms [34]. Further information on StRIP survey development and validation can be found in DeMonbrun et al [9]. The instrument design was originally based on preliminary work from the Pedagogical Expectation Violation Assessment or PEVA [7]. Like the PEVA, our instrument is administered three times during the academic term: at the beginning, two weeks into the course, and at the end of the term. Surveying at the beginning of the term provides data on students' initial expectations of types of instruction, while surveying two weeks later gives additional data on students' expectations of types of instruction. Finally, surveying at the end of the course provides information on students' experiences of different types of instruction as well as data on instructor strategies for using in-class activities and students' response to instruction. The final end of course StRIP survey also provides information on students' expected final grade for the course and on how many active learning courses they have taken prior to the current course. Most measures on the StRIP survey consisted of multiple subscales containing more than one item. Each of the measures are described in the subsequent sections.

3.1.1 Types of Instruction

The types of instruction scale measures the various teaching methods that might occur in a classroom and consists of multiple subscales. The subscales are categorized into passive lecture, active learning lecture, group-based activities, and self-directed activities. Subscales or factors were formed in a preliminary analysis using exploratory and confirmatory factor analysis [9]. All subscales with corresponding items and Cronbach alpha values for this study are provided in Table 1. Cronbach alpha values provide a measure of internal reliability for each subscale [35]. While these subscales do not cover all types of instruction, they provide enough information to draw conclusions about the range of activities occurring in the classroom. Passive lecture covers instruction such as note taking and listening to the instructor. Active learning lecture involves students answering questions and problems posed by the instructor during class. Group based activities describe instances when students engage in groups in both in-class activities and projects outside class. Lastly, self-directed activities describe instances when students have to take responsibility for their own learning, such as working on open-ended problems or brainstorming different solutions to a problem.

3.1.2 Instructor Strategies for Using In-Class Activities

The instructor strategies scale measures student-reported frequency of techniques to reduce student resistance to active learning based on advice from the literature [7, 22, 23, 31, 32] and our prior observations in engineering classrooms [33]. Instructor strategies for using in-class activities fall into two subscales: explanation and facilitation (Table 1). Explanation relates to instructor strategies that describe the purpose of the in-class activity. Facilitation involves instructor strategies that promote engagement and keep the activity running smoothly once it has already begun.

3.1.3 Student Response to Instruction

The student response to instruction scale measures how students react to an in-class and consists of four subscales: value, positivity, participation, and evaluation (Table 1). Value describes how frequently the students found the in-class activity useful. Positivity demonstrates students' outlook towards the in-class activity and the instructor. Participation measures how engaged or resistant students were to the in-class activity. The participation subscale includes items that were reverse coded to provide one direction of engagement (Table 1). Evaluation consisted of two items asking students to rate overall quality of the course and instructor.

3.1.4 Student Characteristics

Measures such as students' expected grades for the course and their amount of prior experiences with active learning (Table 1) might influence how students respond to instruction. Some literature suggests that students may respond more or less favorably to in-class activities based on their expected grade for the course [36, 37]. Controlling for students' prior experiences with active learning allows us to determine if this has an effect on how they respond to instruction. Expected grade was assessed using a single item asking students their anticipated letter grade. Prior experiences with active learning was assessed using a single item asking students how many of their college courses asked them to do an in-class activity at least once a week.

Table 1. StRIP Survey Subscales and Items (Cronbach Alpha Value)

Types of Instruction		
	Passive Lecture ($\alpha = 0.67$)	
		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.
	Active Learning Lecture ($\alpha = 0.78$)	
		Solve problems individually during class.
		Answer questions posed by the instructor during class.
		Ask the instructor questions during class.
	Group Based Activities ($\alpha = 0.81$)	
		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.
	Self-Directed Activities ($\alpha = 0.79$)	
		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.
Instructor Strategies for Using In-Class Activities		
	Explanation ($\alpha = 0.82$)	
		Clearly explained what I was expected to do for the activity.
		Clearly explained the purpose of the activity.
		Discussed how this activity related to my learning.
		Used activities that were the right difficulty level (not too easy, not too difficult).
	Facilitation ($\alpha = 0.71$)	
		Solicited my feedback or that of other students about the activity.

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	Walked around the room to assist me or my group with the activity, if needed.
	Encouraged students to engage with the activity through his/her demeanor.
	Gave me an appropriate amount of time to engage with the activity.
Student Responses to Instruction	
Value (α = 0.86)	
	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.
Positivity (α = 0.73)	
	I felt positively towards the instructor/class.
	I felt the instructor had my best interests in mind.
	I enjoyed the activity.
Participation (α = 0.76)	
	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.*
	I participated actively (or attempted to).
	I tried my hardest to do a good job.
	I pretended but did not actually participate.*
	I rushed through the activity, giving minimal effort.*
Evaluation (α = 0.89)	
	Overall, this was an excellent course.
	Overall, the instructor was an excellent teacher.
Student Characteristics	
Expected Grade	
	What final grade do you expect in this course?
Prior Experiences with Active Learning	
	In how many of your college courses has the instructor asked you to do an in-class activity at least once a week?

* Indicates that these items were reverse-coded.

3.2 Research Design with Independent and Dependent Variables

Student response to instruction was measured using four dependent variables: value, positivity, participation, and evaluation. Independent variables included subscales for four types of instruction: passive lecture, active learning lecture, group-based activities, and self-directed activities. We hypothesized that students' expectations about the type of instruction they would experience as well as the instruction they experienced in the course would affect their response. Since we measure students' expectations of type of instruction twice, and their experiences of type of instruction once, we derive 12 independent variables related to types of instruction. Initial expectations of type of instruction were measured in wave 1 of surveying, expectations of type of instruction two weeks into the course were measured in wave 2, and experiences of type of instruction were measured in wave 3 at the end of the course. We will refer to the type of instruction based on when it was surveyed (e.g,. passive lecture – wave 1, self-directed activities – wave 2, group-based activities – wave 3). In addition to these 12 independent variables, we also utilized the rest of the subscales in Table 1 to have a total of 16 total independent variables. Table 2 provides a summary of all our independent and dependent variables. With so many independent variables, the research design effectively called for a modeling approach that could include numerous variables as predictors to our dependent variables, and this is reflected in our quantitative methods.

Table 2. Summary of Independent and Dependent Variables

Independent Variable	Dependent Variable
Expected Types of Instruction – Wave 1	Student Response to Instruction
Passive Lecture – Wave 1	Value
Active Learning Lecture – Wave 1	Positivity
Group Based Activities – Wave 1	Participation
Self-Directed Activities – Wave 1	Evaluation
Expected Types of Instruction – Wave 2	
Passive Lecture – Wave 2	
Active Learning Lecture – Wave 2	
Group Based Activities – Wave 2	
Self-Directed Activities – Wave 2	
Experienced Types of Instruction – Wave 3	
Passive Lecture – Wave 3	
Active Learning Lecture – Wave 3	
Group Based Activities – Wave 3	
Self-Directed Activities – Wave 3	
Instructor Strategies for Using In-Class Activities	
Explanation	
Facilitation	
Student Characteristics	
Expected Grade	
Prior Experiences with Active Learning	

3.3 Quantitative Methods and Procedure

To answer our research questions, we used a combination of quantitative methods. First, descriptive statistics provided an overview of the dataset with all independent and dependent variables. All variables are subscales consisting of multiple items, and subscale scores are created by taking the average of the multiple items for the individual student. Next, bivariate Pearson correlation analysis was used to determine whether the expectations (wave 1 and wave 2) and experiences of types of instruction (wave 3) as well as instructor strategies for using in-class activities were significantly correlated with student response to instruction. Bivariate Pearson correlation analysis was also used to narrow down which independent variables would be used in the hierarchical multiple linear regression analysis.

Hierarchical multiple linear regression models were created to analyze whether the remaining independent variables were significant predictors of the dependent variables. Hierarchical multiple linear regression models input predictors into the regression model in steps chosen by the researcher to allow for model comparisons in terms of variance explained (R^2) and changing predictor beta (*B*) estimates and other parameters. In other words, this approach allows us to understand whether control variables (expected grade, prior experience) still explain the variance in the outcome variables after the independent variables (expectations, experiences, instructor strategies) are added to the model. Predictors were input into the regression model in the following sequential order: student characteristics, types of instruction – wave 1, types of instruction – wave 2, types of instruction – wave 3, and instructor strategies for using in-class activities. The sequential order was determined by adding control variables first, followed by expectations and experiences of type of instruction chronologically, and finally with instructor strategies added last. Due to the presence of four dependent variables: value, positivity, participation, and evaluation, four hierarchical multiple linear regression models were analyzed. All regression models were examined for assumptions of linearity, normality, homoscedasity, and independence [38]. Due to a violation of normality in the data set, all subscales were log transformed in the linear regression analysis, and log transformation of the data allowed for all assumptions of linear regression modeling to be met. Data cleaning and analysis was performed in R statistical software version 3.2.4.

3.4 Survey Population

This study uses data collected by the research team in Spring 2015. Four courses from three United States institutions (n = 179) were selected through a mix of convenience and purposive sampling. Four instructors were selected and contacted by the research team based on prior knowledge about their active learning instructional methods. All students within each selected course were asked to complete the survey at the beginning, after two weeks, and at the end of the course. A breakdown of students by course and time of survey is provided in Table 3. The number of students surveyed varied across time due to potentially absent students or changing class enrollment. Missing data were removed from the analysis, and missing data in bivariate Pearson correlation and linear regression analysis were accounted for using pairwise deletion which allows for missing data to still be utilized along with other data.

Table 3. Study Population by Course and Survey Time

	Survey Administration Time		
Spring 2015 Courses	Wave 1	Wave 2	Wave 3
University of Texas at Austin – Course 1	58	58	53
University of Texas at Austin – Course 2	66	31	31
North Carolina A&T University	27	31	24
Bucknell University	28	26	26
Total	179	146	134

4. Results

4.1 Descriptive Statistics

StRIP survey instrument subscales' sample size (N), mean, standard deviation (SD), minimum, maximum, skew, and kurtosis are provided in Table 4. More details on numerical coding of subscales are also included in Table 4. The passive lecture type of instruction had the highest mean at wave 1, 2, and 3 (Table 4). It appears that students' expectations of all types of instruction (wave 1 and wave 2) were higher than their experiences of type of instruction (wave 3). Students in these four classes reported a mean frequency of passive lecture corresponding to "often" (M = 3.9, SD = 0.7) and the three other types of instruction corresponding to "sometimes" (type of instruction – wave 3 mean score for active learning lecture, group based activities, and self-directed activities was close to 3). Instructor strategies for using in-class activities was perceived to occur often, as both explanation and facilitation mean scores were close to 4. Expected grades across all students averaged around a B+ (M = 9.9, SD = 2.1). Students on average had active learning experiences in about half of their previous college courses (M = 3.1, SD = 1.1). All student responses to instruction subscale means were close to 4, which suggests that the students responded well when doing an in-class activity in terms of value, positivity, participation, and evaluation.

Table 4. Descriptive Statistics of StRIP Survey Subscales

Factor	N	Mean	SD	Min	Max	Skew	Kurtosis
Types of Instruction[a] – Wave 1							
Passive Lecture	179	4.33	0.58	2.30	5.00	-0.97	1.10
Active Learning Lecture	179	3.73	0.81	1.30	5.00	-0.48	-0.13
Group Based Activities	179	3.36	0.76	1.30	5.00	-0.20	-0.45
Self-Directed Activities	179	3.66	0.56	1.90	5.00	-0.39	0.64
Types of Instruction[a] – Wave 2							
Passive Lecture	146	4.26	0.61	2.30	5.00	-0.82	0.16
Active Learning Lecture	146	3.66	0.81	1.30	5.00	-0.43	-0.14
Group Based Activities	146	3.54	0.91	1.00	5.00	-0.41	-0.58
Self-Directed Activities	146	3.68	0.58	2.10	5.00	-0.07	-0.53
Types of Instruction[a] – Wave 3							
Passive Lecture	134	3.92	0.71	1.00	5.00	-1.01	1.63
Active Learning Lecture	134	3.24	0.85	1.30	5.00	-0.02	-0.94
Group Based Activities	134	3.40	0.67	1.80	4.80	-0.15	-0.57
Self-Directed Activities	134	3.31	0.54	1.70	5.00	0.05	0.19
Instructor Strategies for Using In-Class Activities[a]							
Explanation	134	3.93	0.80	1.30	5.00	-0.77	0.25
Facilitation	134	4.00	0.68	1.30	5.00	-0.81	1.21
Student Response to Instruction[a]							
Value	134	3.92	0.78	1.00	5.00	-0.80	0.68
Positivity	134	3.92	0.74	1.30	5.00	-0.80	0.66
Participation	134	4.04	0.56	1.60	5.00	-1.22	2.61
Evaluation	134	4.25	0.85	1.50	5.00	-1.32	1.18
Student Characteristics							
Expected Grade[b]	133	9.91	2.10	3.00	13.00	-0.87	0.39
Prior Experiences with Active Learning[c]	133	3.09	1.13	1.00	5.00	-0.21	-1.14

[a]Five Point Likert Scale: 1 – Never, 2 – Seldom, 3 – Sometimes, 4 – Often, 5 – Always
[b]13 Point Grade Scale, Min: 1 – F, Max: 13 – A+
[c]Five Point Scale: 1 – None, 2 – A few, 3 – About half of my courses, 4 – Almost all of my courses, 5 – Every course

4.2 Bivariate Correlation Analysis

Types of instruction and instructor strategies for using in-class activities (independent variables) were analyzed for significant correlation with student response to instruction (dependent variables). Bivariate Pearson correlation values are provided in Table 5 with asterisks denoting level of p-value significance.

Expectations of type of instruction at wave 1 and 2 have some statistically significant correlations with student response to instruction (Table 5). Active learning lecture – wave 1 was statistically significantly positively correlated with participation and negatively correlated with evaluation. No other expectations of type of instruction during wave 1 showed statistically significant correlation with student response to instruction. Passive lecture – wave 2 was statistically significantly positively correlated with value and participation. Active learning lecture – wave 2 and value were statistically significantly positively correlated. Group based activities – wave 2 was statistically significantly positively correlated with value, positivity, and evaluation. Self-directed activities – wave 2 was significantly positively correlated with both value and evaluation. It appears that there are statistically significant correlations or relationships between expectations and student response to instruction.

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Experiences of type of instruction at wave 3 and student response to instruction also presented statistically significant correlations (Table 5). Passive lecture – wave 3 was statistically significantly positively correlated with value, positivity, and evaluation. Group based activities – wave 3 was also statistically significantly positively correlated with value, positivity, and evaluation. The other two types of instruction at wave 3, active learning lecture and self-directed activities, did not present statistically significant correlations with student response to instruction. No experiences of type of instruction at wave 3 were statistically significantly correlated with participation.

Instructor strategies for using in-class activities and student response to instruction had many statistically significant correlations (Table 5). Explanation was statistically significantly positively correlated with value, positivity, participation, and evaluation. Facilitation was statistically significantly positively correlated with value, positivity, and evaluation.

Student characteristics and student response to instruction had some statistically significant correlations (Table 5). Expected grade was statistically significantly negatively correlated with value and evaluation, while expected grade and positivity were statistically significantly positively correlated. Prior experiences with active learning was not statistically significantly correlated with student response to instruction.

Table 5. Bivariate Pearson Correlation Values between Independent and Dependent Variables

	Student Response to Instruction			
	Value	Positivity	Participation	Evaluation
Types of Instruction – Wave 1				
Passive Lecture	0.05	0.06	0.09	-0.09
Active Learning Lecture	0.08	-0.04	0.20*	-0.19*
Group Based Activities	0.10	0.02	0.14	-0.09
Self-Directed Activities	0.07	0.05	0.08	-0.04
Types of Instruction – Wave 2				
Passive Lecture	0.25*	0.15	0.25*	0.08
Active Learning Lecture	0.22*	0.06	0.15	0.07
Group Based Activities	0.40***	0.22*	-0.03	0.34***
Self-Directed Activities	0.25*	0.07	0.10	0.22*
Types of Instruction – Wave 3				
Passive Lecture	0.29***	0.27**	0.14	0.33***
Active Learning Lecture	0.10	0.09	0.02	0.02
Group Based Activities	0.36***	0.30***	0.01	0.30***
Self-Directed Activities	0.16	0.15	0.02	0.16
Instructor Strategies for Using In-Class Activities				
Explanation	0.56***	0.66***	0.24**	0.67***
Facilitation	0.58***	0.60***	0.15	0.63***
Student Characteristics				
Expected Grade	-0.17*	0.31***	0.06	-0.41***
Prior Experiences with Active Learning	0.11	0.02	0.16	-0.09

*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$*

4.3 Hierarchical Multiple Linear Regression Analysis

Following the correlation analysis, we performed hierarchical multiple linear regression analysis for each of the four dependent variables. Only independent variables with statistically significant correlations to a corresponding dependent variable (Table 5) were included in the hierarchical regression model. Independent variables or predictors were entered into the regression model in steps. Tables 6-9 present summaries of the four hierarchical regression models with variance accounted for by each step (R^2), the change in variance accounted for from the previous step (ΔR^2), Beta estimates (B), standard errors of the Beta estimates (SE B), and standardized Beta estimates (*B*). Statistically significant predictors are denoted with an asterisk. All hierarchical regression models were statistically significant.

The hierarchical regression analysis predicting value consisted of four steps (Table 6). Step 1 input expected grade to predict value, and expected grade was a statistically significant negative predictor of value. Step 2 input passive lecture – wave 2, active learning lecture – wave 2, group based activities – wave 2, and self-directed activities – wave 2, in addition to expected grade to predict value. Expected grade was not a statistically significant predictor of value in this step, but passive lecture – wave 2 and group based activities – wave 2 were statistically significant positive predictors of value. Step 3 input passive lecture – wave 3 and group based activities – wave 3 in addition to the previous predictors to predict value, and passive lecture – wave 2 and group based activities – wave 3 were statistically significant positive predictors of value. Finally, step 4 input explanation and facilitation into the model, and passive lecture – wave 2, group based activities – wave 3, and explanation were statistically significant positive predictors of value. R^2 values increased from step to step, and the final model, step 4, accounted for 44% of the variance when predicting value. Thus, in the final model, value is predicted by students' wave 2 expectations for passive lecture, wave 3 experience of group based activities, and instructor strategies for explanation of active learning activities. Although expected grade alone described a small amount of the variance in value in Step 1, it is not a significant predictor when the other variables are included.

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Table 6. Summary of Hierarchical Regression Analysis for Variables Predicting Value

Step and Variable	R^2	ΔR^2	B	SE B	*B*
Step 1	0.03				
Constant			0.97*	0.16	
Expected Grade			-0.03	0.02	-0.17*
Step 2	0.22	0.19			
Constant			0.36	0.22	
Expected Grade			-0.01	0.02	-0.05
Passive Lecture – Wave 2			0.25	0.11	0.23*
Active Learning Lecture – Wave 2			0.03	0.12	0.03
Group Based Activities – Wave 2			0.39	0.13	0.40*
Self-Directed Activities – Wave 2			-0.07	0.18	-0.05
Step 3	0.28	0.05			
Constant			0.03	0.26	
Expected Grade			0.00	0.02	0.00
Passive Lecture – Wave 2			0.28	0.11	0.26*
Active Learning Lecture – Wave 2			0.02	0.12	0.02
Group Based Activities – Wave 2			0.21	0.15	0.21
Self-Directed Activities – Wave 2			-0.02	0.17	-0.02
Passive Lecture – Wave 3			-0.03	0.13	-0.02
Group Based Activities – Wave 3			0.41	0.17	0.30*
Step 4	0.44	0.16			
Constant			-0.29	0.25	
Expected Grade			0.02	0.02	0.09
Passive Lecture – Wave 2			0.21	0.10	0.19*
Active Learning Lecture – Wave 2			0.05	0.10	0.05
Group Based Activities – Wave 2			0.09	0.13	0.09
Self-Directed Activities – Wave 2			-0.01	0.16	-0.01
Passive Lecture – Wave 3			-0.13	0.12	-0.11
Group Based Activities – Wave 3			0.34	0.15	0.25*
Explanation			0.26	0.13	0.26*
Facilitation			0.30	0.17	0.24

$*p \leq 0.05$

The hierarchical regression analysis for predicting positivity also consisted of four steps (Table 7). Step 1 input expected grade, and expected grade was a statistically significant negative predictor of positivity. Step 2 input group based activities – wave 2 with expected grade, and expected grade remained a statistically significant negative predictor of positivity. Step 3 input passive lecture – wave 3 and group based activities – wave 3 with the previous predictors, and expected grade remained a statistically significant negative predictor of positivity, while group based activities – wave 3 was a statistically significant positive predictor of positivity. Step 4 input explanation and facilitation into the model along with the previous predictors, and expected grade was not a statistically significant predictor of positivity, while group based activities – wave 3, explanation, and facilitation were statistically significant positive predictors of positivity. The final hierarchal regression model for predicting positivity, step 4, accounted for 56% of the variance, and R^2 values increased from step to step with the biggest increase from adding explanation and facilitation to the model. In this final model, positivity is predicted by students' reported frequency of group-based activities and instructor strategies for explanation and facilitation. Again, expected grade is not a significant predictor when other aspects of instruction are added to the model.

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Table 7. Summary of Hierarchical Regression Analysis for Variables Predicting Positivity

Step and Variable	R^2	ΔR^2	B	SE B	*B*
Step 1	0.09				
Constant			1.18*	0.14	
Expected Grade			-0.05	0.01	-0.31*
Step 2	0.14	0.05			
Constant			1.08*	0.20	
Expected Grade			-0.05	0.02	-0.31*
Group Based Activities – Wave 2			0.15	0.09	0.17
Step 3	0.18	0.04			
Constant			0.79*	0.25	
Expected Grade			-0.04	0.02	-0.26*
Group Based Activities – Wave 2			0.01	0.11	0.01
Passive Lecture – Wave 3			0.02	0.11	0.02
Group Based Activities – Wave 3			0.34	0.16	0.26*
Step 4	0.56	0.38			
Constant			0.28	0.19	
Expected Grade			-0.02	0.01	-0.09
Group Based Activities – Wave 2			-0.11	0.09	-0.13
Passive Lecture – Wave 3			-0.16	0.09	-0.14
Group Based Activities – Wave 3			0.27	0.12	0.21*
Explanation			0.45	0.10	0.48*
Facilitation			0.31	0.13	0.27*

*$p \leq 0.05$

The hierarchical regression analysis for predicting participation consisted of three steps (Table 8). Step 1 input active learning lecture – wave 1 into the model, and active lecture – wave 1 was a statistically significant positive predictor of participation. Step 2 input passive lecture – wave 2 and active learning lecture – wave 1 into the model, and neither were statistically significant predictors of participation. Step 3 input explanation with passive lecture – wave 2 and active learning lecture – wave 1 into the model, and all three were not statistically significant predictors of participation. R^2 value of the final model, step 3, only accounted for 12% of the variance. In sum, the final model for participation does not include any of our independent variables as significant predictors.

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Table 8. Summary of Hierarchical Regression Analysis for Variables Predicting Participation

Step and Variable	R^2	ΔR^2	B	SE B	*B*
Step 1	0.09				
Constant			0.54*	0.06	
Active Learning Lecture – Wave 1			0.15	0.07	0.20*
Step 2	0.09	0.00			
Constant			0.49*	0.07	
Active Learning Lecture – Wave 1			0.12	0.08	0.18
Passive Lecture – Wave 2			0.17	0.09	0.21
Step 3	0.12	0.03			
Constant			0.40*	0.09	
Active Learning Lecture – Wave 1			0.14	0.08	0.20
Passive Lecture – Wave 2			0.13	0.09	0.15
Explanation			0.15	0.09	0.19

$*p \leq 0.05$

The hierarchical regression analysis for predicting evaluation consisted of five steps (Table 9). Step 1 input expected grade into the model, and expected grade was a statistically significant negative predictor of evaluation. Step 2 input active learning lecture – wave 1 with expected grade, and expected grade remained a statistically significant predictor of evaluation. Step 3 input group based activities – wave 2 and self-directed activities – wave 2 with the previous predictors. Expected grade and active learning lecture – wave 1 were statistically significant negative predictors of evaluation, while group based activities – wave 2 was a statistically significant positive predictor of evaluation. Step 4 input passive lecture – wave 3 and group based activities – wave 3 in addition to the previous predictors into the model, and expected grade and active learning lecture – wave 1 were statistically significant negative predictors of evaluation. Finally, step 5 input explanation and facilitation to the model, and active learning lecture – wave 1 was a statistically significant negative predictor of evaluation, and explanation was a statistically significant positive predictor of evaluation. The R^2 value for the final model, step 5, accounted for 58% of the variance when predicting evaluation. There was a drop in R^2 values from step 1 to step 2 due to missing data and changing degrees of freedom. The biggest change in R^2 values came from the addition of explanation and facilitation to the model. In the final model for evaluation, wave 1 expectations for active learning lecture was a significant negative predictor, and instructor strategies for explanation was a significant positive predictor. Again, expected grade is not a significant predictor when other aspects of instruction are added to the model.

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Table 9. Summary of Hierarchical Regression Analysis for Variables Predicting Evaluation

Step and Variable	R^2	ΔR^2	B	SE B	*B*
Step 1	0.17				
Constant			1.30*	0.17	
Expected Grade			-0.08	0.02	-0.41*
Step 2	0.15				
Constant			1.35*	0.21	
Expected Grade			-0.07	0.02	-0.34*
Active Learning Lecture – Wave 1			-0.19	0.10	-0.18
Step 3	0.28	0.13			
Constant			1.07*	0.26	
Expected Grade			-0.06	0.02	-0.29*
Active Learning Lecture – Wave 1			-0.34	0.11	-0.33*
Group Based Activities – Wave 2			0.32	0.15	0.29*
Self-Directed Activities – Wave 2			0.12	0.20	0.08
Step 4	0.34	0.06			
Constant			0.53	0.33	
Expected Grade			-0.05	0.02	-0.23*
Active Learning Lecture – Wave 1			-0.45	0.12	-0.44*
Group Based Activities – Wave 2			0.14	0.17	0.13
Self-Directed Activities – Wave 2			0.21	0.20	0.15
Passive Lecture – Wave 3			0.27	0.15	0.18
Group Based Activities – Wave 3			0.39	0.20	0.24
Step 5	0.58	0.25			
Constant			-0.01	0.28	
Expected Grade			-0.02	0.02	-0.10
Active Learning Lecture – Wave 1			-0.34	0.10	-0.33*
Group Based Activities – Wave 2			0.07	0.14	0.06
Self-Directed Activities – Wave 2			0.18	0.16	0.13
Passive Lecture – Wave 3			0.06	0.12	0.04
Group Based Activities – Wave 3			0.29	0.16	0.18
Explanation			0.51	0.13	0.44*
Facilitation			0.21	0.17	0.14

*$p \leq 0.05$

5. Discussion

Through descriptive statistics, bivariate Pearson correlation analysis, and hierarchical regression analysis, we were able to answer our research questions. The first three research questions asked about the presence of a relationship between expectations of type instruction, experiences of type of instruction, and instructor strategies for using in-class activities with student response to instruction; Table 5 lists the bivariate Pearson correlations. Five of eight variables describing expectations for type of instruction (waves 1 and 2) presented statistically significant relationships with at least one of the four student response to instruction variables. Two of four type of instruction variables (wave 3) were statistically significantly correlated with value, positivity, or evaluation. Both instructor strategies for using in-class activities also contained statistically significant correlations with three or four of the student response to instruction variables. In terms of our first three research questions, there are indeed statistically

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significant relationships between expectations of type of instruction, experiences of type of instruction, instructor strategies for using in-class activities, and student response to instruction. We used these relationships to predict student response to instruction, and this answered our last research question.

5.1 Significant Predictors of Student Response to Instruction

Significant predictors from the last step of the hierarchical regression model for each of the four dependent variables (value, positivity, participation, and evaluation) are summarized in Table 10. Of the multitude of relationships suggested by the bivariate Pearson correlation analysis, only a few independent variables were statistically significant predictors of student response to instruction.

Table 10. Summary of Significant Predictors of Student Response to Instruction from Final Models

Value
Passive Lecture – Wave 2
Group Based Activities – Wave 3
Explanation
Positivity
Group Based Activities – Wave 3
Explanation
Facilitation
Participation
None
Evaluation
Active Learning Lecture – Wave 1[a]
Explanation

[a]Negative Predictor

Student characteristics such as expected grade were input first into the hierarchical regression models. However, prior experiences with active learning did not have any statistically significant correlations with student response to instruction (Table 5), so it was not included in any of the hierarchical regression models. Interestingly, expected grade was a statistically significant predictor of student response to instruction in many early steps of each analysis, but it was not a statistically significant predictor in any of the final models (Table 10). Contrary to common belief, neither students' expectations of their grade nor amount of prior experience with active learning appear to be a statistically significant predictor of how students respond to instruction when other aspects of instruction are considered, at least in this data set.

Students' expectations regarding the type of instruction they would experience in the course had very little relationship to their response to the instruction. Early steps of hierarchical regression analysis identified more statistically significant relationships between students' expectations and student response to instruction, but these predictors were not statistically significant when combined with experiences of type of instruction and instructor strategies in later models. Only active learning lecture – wave 1 and passive lecture – wave 2 were significant predictors of student response to instruction in the final models (Table 10). Having an initial expectation that a course would include active lecture negatively influenced the way students evaluated a course, while having the expectation after two weeks of instruction that a course would include passive lecture positively affected the value a student placed on the instruction.

Students' experiences of type of instruction at wave 3 presented only one statistically significant predictor, group based activities – wave 3, which was a statistically significant predictor of value and positivity. Students who reported higher frequency of group based activities placed greater value and had higher levels of positivity towards in-class activities than students who reported lower frequency. Thus these type of in-class activities are especially promising for favorable student responses to active learning. It was surprising that group based activities stood out from the other types of instruction with respect to this relationship to student reaction.

Instructor strategies for using in-class activities were statistically significant predictors of student response to instruction. Explanation was a statistically significant predictor of value, positivity, and evaluation, while facilitation was a statistically significant predictor of positivity (Table 10). Further, in the models for positivity and evaluation (Tables 7 and 9), addition of these strategies accounted for the largest ΔR^2 change in variance explained, or arguably the strongest set of predictors. When instructors explained the purpose of the activities, students placed greater value on the activities, had higher positivity towards them, and evaluated the course higher. As well, when instructors assisted in facilitating the in-class activities, students valued the activities more. This is a key finding. If instructor strategies are the biggest determinant of how students respond to active learning, this suggests that targeted faculty development efforts may go a long way towards reducing the degree of student resistance encountered and thereby increase the diffusion of active learning into practice.

Interestingly, our data set revealed no significant predictors of student participation in the in-class activities. We suspect that, rather than suggesting there is nothing an instructor can do to influence student participation, the small number of students in our data set and the overall high levels of participation did not allow sufficient variance in the data to detect such predictors.

5.2 Limitations of Quantitative Analysis

Though the quantitative methods used to answer our research questions were useful and helpful for drawing conclusions, there are some limitations of our analysis. This analysis relied heavy on StRIP survey data, which utilizes student self-reported data on their perceptions and experiences as well as the instructor's strategies. A primary concern with self-reported data is that students may perceive different experiences of types of instruction as well as the frequency of instructor strategies for using in-class activities. However, students' perceptions of the type of instruction and the instructor are still important as they may relate strongly to their attitudes and behaviors with respect to active learning. In addition to using self-reported data, there may be generalizability limitations due to using a smaller preliminary data set from a few institutions. The data set only utilized four instructors, and there may be selection bias as these instructors might have volunteered due to their expertise in active learning instruction. It could be the case that these four instructors are unlike other engineering instructors, and more work needs to be done to determine how much instructor's previous experiences and confidence with active learning relates to their ability to reduce student resistance. Though it could be the case that these instructors are exemplars in active learning instruction, there is still evidence to support our finding that the instructor has a significant effect on students' response to active learning. For newer and more inexperienced instructors, these results should be considered in regards to how well these four instructors were able to explain and facilitate their active learning activities. A larger and more diverse data set should be utilized to examine and generalize these results across engineering classrooms in U.S. institutions.

5.3 Implications for Instruction

The results of this study have several practical implications for instructors. Perhaps most importantly, the data show no significant negative correlation between any type of instruction and any student response to instruction (Table 5). In particular, there was no evidence found to support the common concern that instructor or course evaluations are negatively affected by adopting active learning strategies. This is further supported by student response to instruction data on individual variables. For example, the average student response to instruction on the value, positivity, and participation subscales was approximately 4 out of 5 (Table 4). This means that students more often than not participated fully in the activities, saw educational value in them and enjoyed them. This is consistent with the positive Pearson correlation values in Table 5, which show that students did not generally react negatively to the active learning techniques employed by instructors in this study. The data presented in this analysis also confirms earlier preliminary work [39] about the lack of student resistance. This should be encouraging to instructors wanting to use active learning but who are concerned about student resistance. While the results presented do not imply individual students might not react negatively to active learning, they do suggest that instructors have no strong reason to believe that adopting active learning will generally lead to lower overall evaluations of the course or instructor.

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The data on group based activities is particularly encouraging. Table 5 indicates that students found group based activities to be both positive and valuable learning experiences. The experiences of group activities also correlated positively with the overall evaluation of the course and instructor. The implication for instructors is that group activities are likely to be viewed positively by students more often than generating student resistance. The data presented here, which is consistent with the broader literature on cooperative and collaborative learning [2, 15, 23], suggest that student resistance to group activities is not the majority view. Once resistant students see that, they may accept group activities with fewer complaints, perhaps even long enough to experience the educational benefits of group activities demonstrated consistently in the literature.

The most statistically powerful predictor of student response to instruction was not the type of instruction itself but the instructor strategies used to implement that instruction. In particular, there was a strong positive correlation between the explanation and facilitation strategies monitored in this study and several student responses to instruction, including the overall evaluation of the course and instructor. The implications are clear and lend credence to many of the suggestions found in the literature [7, 22, 23, 31]. Instructors planning to adopt active learning would be well advised to consider these strategies. Specifically, instructors should choose activities of appropriate difficulty, clearly explain what students are expected to do during the activity and clarify the benefit of the activity for students. In addition, instructors should set the stage for successful activities by providing appropriate time and by encouraging student engagement through their demeanor and interactions with the class. Clearly, instructors have a great deal of influence on how students respond to active learning. The results presented here provide evidence-based strategies for both reducing resistance and encouraging a positive student response.

5.4 Searching for Expectancy Violation

There is limited prior work to guide this study of student response to active learning, particularly in engineering courses. One of the only existing theories is expectancy violation [7], which states that students come to STEM courses expecting traditional lecture and resist when asked to engage in active learning. Following Gaffney et al. [7], we surveyed students at the beginning of their classes and after two weeks to measure expectations in addition to experience of various instructional practices. However, in our preliminary analyses, these expectations were rarely significant predictors of any of our student response to instruction variables in the final models presented in Tables 8, and this is consistent with our other preliminary analysis [39]. Of a possible eight expectation variables predicting four outcomes, only two combinations were significant. Passive lecture – wave 2 was a significant predictor of value (Table 10); students who expected greater frequency of passive lecture by the second week of class were more likely to value active learning activities. Active lecture – wave 1 was a significant predictor of evaluation (Table 10); students who initially expected greater frequency of active lecture tended to rate the instructor and course lower at the end of the term.

There are several important implications of these results. First, in this data set there is limited evidence to support expectancy violation as a viable explanation for student resistance to active learning. Second, a number of other factors over which instructors have much more control have more significant relationships with student response to active learning: actual frequency of group based activities, explanation instructor strategies, and facilitation instructor strategies as described above. To be fair, Gaffney and coworkers advocate some of the same instructor strategies to adjust students' expectations in the first weeks of class. More work should also be done examining if less effective instructors encounter expectancy violation with their students. While our preliminary results do not support their underlying explanation for student resistance, the final recommendations are similar and reinforced by the results of studies conducted in both engineering and physics undergraduate settings.

6. Conclusion and Future Work

The goal of this study was to investigate the common instructor concern that students will respond negatively to active learning instruction. This concern is often given as a reason not to adopt or to discontinue use of active learning. We used the StRIP survey that we previously developed and validated to collect data from 179 students in four classes at three U.S. institutions. Results were analyzed using bivariate Pearson correlation analysis and hierarchical multiple linear regression modeling.

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The most important conclusion from this study is that we found no evidence to support the common concern that instructor or course evaluations are negatively affected by adopting active learning strategies. This finding should serve as a reassurance to instructors who are hesitant to adopt active learning for fear of student resistance. Our findings suggest that students more often than not saw educational value in them, felt positively about them, and participated fully in the active learning activities. We also found evidence that the way instructors explain and facilitate active learning instruction influences student reactions. These findings corroborate the advice in the literature that has been previously based on more anecdotal evidence. In particular, when using active learning, instructors should choose activities of appropriate difficulty, clearly explain what students are expected to do during the activity, and clarify the benefit of the activity for students. It is also important for instructors to be sure to provide appropriate time and encourage student engagement through their demeanor and interactions with the class.

In future work we intend to verify these findings with a larger and broader sample of students from a wider variety of institutions. This will enable us to develop more sophisticated statistical analyses and more generalizable results. More work will also be done focusing on the role of the instructor and how the instructor's background, years of experience, and confidence with active learning relates to their use of active learning in the classroom.

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