Student Resistance to Active Learning: Do Instructors (Mostly) Get It Wrong?

Madison E. Andrews[1] (ORCID: 0000-0002-9653-9785), Matthew Graham[2] (ORCID: 0000-0002-0235-5126), Michael Prince[3], Maura Borrego[1] (ORCID: 0000-0001-7131-4611), Cynthia J. Finelli[4] (ORCID: 0000-0001-9148-1492), Jenefer Husman[2] (ORCID: 0000-0002-6454-6817)

Corresponding Author & Email: Maura Borrego, maura.borrego@austin.utexas.edu

Authors' Affiliations:
[1]The University of Texas at Austin, Austin, TX, United States
[2]University of Oregon, Eugene, OR, United States
[3]Bucknell University, Lewisburg, PA, United States
[4]University of Michigan, Ann Arbor, MI, United States

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Abstract

Adopting evidence-based teaching practices, such as active learning, has proven to increase student learning, engagement, and interest in STEM and subsequently, the number and diversity of STEM graduates. Despite these compelling findings, the translation of educational research to classrooms has been slow, in part due to instructors' concerns about student resistance.

To better understand STEM instructors' and students' attitudes and behaviors regarding active learning, we administered surveys to instructors and their students and conducted classroom observations. The instructor survey measured their attitudes towards & use of active learning, strategies used to reduce student resistance, and perceptions of student behavior. The corresponding student survey asked students to evaluate their instructors' teaching practices, as well as students' own attitudes and behaviors during class that day. Classroom observations supplemented these metrics.

Analyses of matched survey datasets (n=28, n=780) and observations (n=14) reveal a disconnect between instructor perceptions of their students' responses to active learning and students' self-reported attitudes and behaviors, where instructors overestimate student resistance. In contrast, students report they see value in the activities, enjoy them, and even plan to highly evaluate the course and instructor at the end of the semester. Overall, these results suggest that instructors' fears about adopting these teaching practices are largely erroneous.

Key Words: active learning ○ higher education ○ instructional change ○ adoption

1. Introduction

1.1. Active Learning

An overwhelming body of literature documents the benefits of instructors adopting active learning techniques in their classrooms, including improved student learning and performance in STEM disciplines (Freeman et al., 2014; Haak, HilleRisLambers, Pitre, & Freeman, 2011) and in engineering, specifically (Lucke, Dunn, & Christie, 2017; Prince & Felder, 2006). These teaching practices have also been proven to increase student engagement and subsequently, interest in STEM (Seymour & Hewitt, 1997) and in engineering (Lucke et al., 2017; Prince, 2004; K. Smith, Sheppard, Johnson, & Johnson, 2005). Moreover, active learning has been hypothesized to be particularly effective for educating a diverse student body and increasing retention in STEM (Chi & Wylie, 2014; Freeman et al., 2014; Haak et al., 2011; Lucke et al., 2017; Prince, 2004; Prince & Felder, 2006; Seymour & Hewitt, 1997).

Despite these compelling findings, the translation of this research to classrooms has been slow (Dancy, Henderson, & Turpen, 2016; Hora, Ferrare, & Oleson, 2012; Jamieson & Lohmann, 2012; National Research Council, 2012), especially in STEM, where the majority of classrooms are still taught using lecture-based methods (Stains et al., 2018). This cannot be credited to insufficient awareness; a survey of engineering instructors found the majority of instructors were aware of these techniques, but less than half had adopted them (Borrego, Froyd, & Hall, 2010). Instead, research has identified several barriers that may be slowing the adoption of active learning in STEM classrooms (Finelli, Richardson, & Daly, 2013; Froyd, Borrego, Cutler, Henderson, & Prince, 2013; Henderson & Dancy, 2007; Prince, Borrego, Henderson, Cutler, & Froyd, 2013), and subsequently, preventing the many benefits of these techniques from reaching as many students as possible (Borrego et al., 2010; Stains et al., 2018).

1.2. Barriers to Instructional Change

As such, it is essential to increase the use of evidence-based teaching practices, specifically active learning, among STEM instructors. Our prior work has identified barriers to the adoption of these practices, as reported by engineering instructors, including concerns about: 1) their efficacy; 2) the preparation time required to implement them; 3) use of classroom time and corresponding concerns about covering a curriculum; and finally, 4) student resistance (Finelli et al., 2013; Froyd et al., 2013; Prince et al., 2013). The literature has explored the first three of these concerns and thoroughly documents both the efficiency and effectiveness of these practices (e.g., Felder & Brent, 2009; Freeman et al., 2014; Prince, 2004).

1.3. Student Resistance

Extant literature has named several types and characteristics of student resistance (DeMonbrun et al., 2017; Nguyen, Husman, et al., 2017; Seidel & Tanner, 2013; Weimer, 2002). Here, we define *student resistance* as any negative behavioral or attitudinal response to a teaching practice that could discourage instructors from using active learning. Students may be resistant to new instructional methods because student-centered activities may require more effort, may require students to attempt a task they do not feel efficacious at or see value in, or may be outside of students' assumptions about teaching and learning (Åkerlind & Trevitt, 1999; Alpert, 1991; Cooper, Ashley, & Brownell, 2017; Keeley, Shemberg, Cowell, & Zinnbauer, 1995).

Despite student resistance being one of the most actionable barriers to STEM instructional change, little research specifically explores it with respect to active learning. One of the few extant studies characterizes student resistance to active learning into three basic levels: passive, partial compliance, and open resistance (Weimer, 2002). However, our prior work in engineering classrooms has shown that students rarely resist active learning in openly confrontational ways (Nguyen, Husman, et al., 2017); instead, they tend to simply work on something besides the assigned task (Shekhar et al., 2015). Therefore, we examine student resistance using a validated instrument that assess five measures of student responses to different teaching practices: *value, positivity, participation*, *distraction*, and *evaluation* of the instructor or course (DeMonbrun et al., 2017; Shekhar et al., 2015).

1.3.1. Strategies to Reduce Student Resistance

There are, however, effective strategies instructors can use to reduce student resistance when implementing active learning in STEM classrooms (Finelli et al., 2018; Nguyen, Husman, et al., 2017; Tharayil et al., 2018). *Explanation* strategies emphasize how an instructor can frame the purpose and the goal of the activity. *Facilitation* strategies focus on how to better engage students in the activity. Examples of these strategies have been detailed in our prior work (e.g. Finelli & Borrego, 2020). Use of these strategies has been proven to correlate with lower levels of student resistance, and as such, these strategies show promise in eliminating a barrier to adoption and continued us of active learning in STEM classrooms (Finelli et al., 2018; Nguyen, DeMonbrun, et al., 2017; Tharayil et al., 2018). Additional work is required to understand whether these strategies, when adopted by less experienced instructors, can be shown to reduce resistance.

1.4. Student & Instructor Perceptions

At the foundation of student resistance, and subsequently strategies to reduce it, lies instructors' perceptions of their classrooms and students' perceptions of instructional techniques. Explorations of the latter have indicated that despite instructors' concerns about resistance (Finelli et al., 2013; Froyd et al., 2013; Prince et al., 2013), students actually report that they value engaging learning activities (Lumpkin, Achen, & Dodd, 2015), find courses that use them to be much better designed than lecture-based courses (Chiu & Cheng, 2017; Miller & Metz, 2014), and affirm that these activities positively impact both their learning (Lumpkin et al., 2015; Miller & Metz, 2014; V. Smith & Cardaciotto, 2011) and their creativity (Chiu & Cheng, 2017). Yet, a comparison of active and passive classrooms found that while students both learn more in active classrooms and respond positively to active learning, they self-report learning less in active classrooms than in passive ones (Deslauriers, McCarty, Miller, Callaghan, & Kestin, 2019). Though students may not always enjoy active learning, the literature suggests they value any instruction that directly relates to improving their performance in the course, active or otherwise (Machemer & Crawford, 2007).

Still, instructors' fears of student resistance remain a well-documented barrier to adoption, and as such, there is an apparent disconnect between students' actual responses to active learning and instructors' predictions and perceptions of student responses. Exploring this divide, researchers asked students why they believed their instructors did not implement active learning and found students believed instructors were simply more comfortable lecturing or did not see active learning techniques as useful (Miller & Metz, 2014); surveys polling the instructors for their reasoning conversely echoed the barriers to adoption noted above (Finelli et al., 2013; Froyd et al., 2013; Henderson & Dancy, 2007; Miller & Metz, 2014;

Prince et al., 2013), rather than reflecting the opinions of their students. A follow-on study found that while STEM students and instructors agree that active learning is useful and effective, they disagree on how often it is used, where instructors overestimate time spent on active learning (Patrick, Howel, & Wischusen, 2016). Moreover, they found not only that STEM students enjoyed active learning, but also that they felt more of class time should be devoted to it (Patrick et al., 2016). These compelling results beg the question, what if instructors are simply wrong about perceived student resistance to active learning? Yet, metrics of student resistance are left largely unexplored in these comparisons.

1.5. Research Questions

Using data collected from instructor and student surveys and corresponding classroom observations, we seek to understand the following:

1. How do STEM instructors believe students respond to the implementation of active learning?
    a) Specifically, how do instructors report levels of student resistance?
2. How do STEM students actually perceive and react to instructors' use of active learning?
    a) Specifically, how do students self-report levels of resistance?
3. How, if at all, do instructors' perceptions and self-reported student responses correlate?

In doing so, we expand upon prior understandings of student resistance and strategies to reduce it in STEM classrooms, using empirical methods and validated instruments. Uniquely, this study examines the above questions with diverse student populations and in a variety of educational settings.

2. Methods

2.1. Participant Recruitment

Instructors were recruited via email, as part of a broader study where they attended a workshop on active learning in undergraduate STEM classrooms. Here, we define STEM as including chemistry, computer and information sciences, engineering, geosciences, life sciences, materials research, mathematical sciences, and physics/astronomy (United States Government Accountability Office, 2014). To identify workshop participants, we first compiled a list of all 2-year and 4-year institutions of higher education offering at least one STEM degree program within 150 miles of Austin, TX, United States (n=50); 2-year institutions typically offer associate's degrees and early coursework that may be transferred to a 4-year institution to be counted toward a bachelor's degree. Then, we used each institution's public website to identify a contact within each STEM department, who was asked to distribute a recruitment letter to fellow instructors and to consider applying themselves. In most cases, an administrator (e.g. Department Chair) was contacted; else, all listed STEM instructors were contacted directly.

Recruitment materials advertised an opportunity to both attend a one-day active learning workshop and to participate in classroom-based data collection the following semester (Fall 2019). Instructors were eligible to participate in the study if they were teaching a first- or second-year STEM course, planned to use active learning during the Fall 2019 semester, and were available to attend the workshops in May of 2019. A total of 39 instructors were invited to participate; 28 attended a workshop and participated in classroom-based data collection in one of their courses the following semester. A demographic and academic overview of our participants is reported in Table 1.

2.2. Data Collection

To better understand STEM instructors' and students' attitudes and behaviors regarding active learning, we administered online surveys to instructors and their students and conducted classroom observations. Instructors were asked to identify one STEM course in which they planned to use active learning for data collection. The instructor survey measured instructors' attitudes towards and use of active learning, strategies used to reduce student resistance, and perceptions of student behavior. The corresponding student survey asked students to evaluate their instructors' teaching practices, as well as students' own attitudes and behaviors during class that day. Classroom observations supplemented these metrics. All data collection took place in-person during the Fall 2019; surveys and observations each refer to the same class period of one course.

2.2.1. Instructor Survey

Our instructor survey collected data on eight validated metrics in three main categories: use of active learning, use of instructor strategies, and student responses (Graham & Husman, 2020). First, instructors were prompted to reflect on their general approach to teaching and report their propensity to use *active learning* (α=0.70). Additionally, instructors were guided to reflect on their behaviors in the course of interest and report their use of explanation and facilitation strategies on 10-point Likert-type scales. *Explanation* strategies emphasize how an instructor can frame the purpose and the goal of the activity (α=0.85). *Facilitation* strategies focus on how to better engage students in the activity (α=0.88). Additionally, for a specific class period, instructors were asked to indicate how their students responded to active learning activities on five affective and behavioral metricson a specific target class period in five areas, all measured on seven-point Likert-type scales: *value* (α=0.61), *positivitiy* (α=0.66), *participation* (α=0.57), *distraction* (α=0.47) and *evaluation* (α=0.97). Instructors rated whether they believed their students saw value in the activities, reacted positively towards them, participated in or were distracted from them, and how they believe students would evaluate their course as a result of the activities, respecitvely.

Internal reliability was acceptable for six of the eight instructor measures; however, instructors' reports of students' *participation* and *distraction* were below the generally accepted value of 0.60. Further analysis revealed skewed and kurtotic items on these scales that may account for the lack of internal consitency. Rather than bias our results by omiting or transforming these items, we retained these items when constructing mean-scores for the present analyses. Instructors' responses were averaged across all items within each of the eight factors to create a mean score for each measure. We report descriptive statistics in and correlations between instructor survey measures in Table 2.

2.2.2. Student Survey

Student survey measures were adapted from the surveys developed in our prior work and correspond directly with the eight items included on the instructor survey (DeMonbrun et al., 2017). Students were first prompted to report instructors' general use of *active learning* in their course (α=0.89) and their instructors' use *explanation* (α=0.86) and *facilitation* (α=0.80) strategies during a specifc class period. Then, students were asked to report their own affective and behavioral response to any active learning activies during the specific class period, including their *value* (α=0.90), *positivity* (α=0.81), *participation* (α=0.74), *distraction* (α=0.70), and *evaluation* (α=0.91) of the instructor. Students' report of instructors' active learning use was measured on a 10-point Likert-type scale. All other items were measured using a seven-point Likert-type scale.

Mirroring data processing for instructor-level items, students' responses were averaged across all items within factors to create a mean score for each measure. Then, student reports were averaged within each classroom to avoid biasing our analysis by the uneven number of students in each class. As a sensitivity analysis, we conducted all analyses with both the student-level and class average student response. We did not detect any change in the patterns of relations or statistical significance; as such, all results are reported here using the class-mean student response. We report descriptive statistics in and correlations between student survey measures in Table 3.

2.2.3. Observation Measures.

We developed observational instruments to evaluate five observable measures of instructor and student behavior in class. *Active learning* use was measured by calculating the percent of class time instructors used for non-lecture activities. *Explanation* and *facilitation* strategy use was calculated by identifying the frequency with which instructors used specific strategies throughout each non-lecture activity. Observable student engagement factors, including *participation* and *distraction,* were measured by evaluating students' behavior at the beginning, middle, and end of each non-lecture activity. The current version of this instrument has an intraclass correlation coefficient of 0.84. However, all observations in the present analysis were conducted by the same researcher.

2.3. Statistical Analyses

We calculated descriptive statistics of instructors' and students' responses on their respective surveys to answer our first two research questions. To answer our third, we first evaluated agreement between survey and observation data for each of the eight factors (e.g., agreement in *active learning* use between student report, instructor report, and observation) as a measure of convergent validity (e.g. Crocker & Algina, 1986). We opted to use Pearson correlation rather than other measures of consistency of reliability, as the scales used to measure items was not identical across each data source. In order to establish convergent validity, we examined both statistical significance and overall strength of the relationship for each factor between data source. Given that our analysis examined matching constructs measured from three perspectives, rather than similar or related constructs, we established a high threshold for the strength of relation, suggesting convergent validity at $r > 0.50$ (Swank & Mullen, 2017).

Second, to evaluate the degree to which the relationship pattern was similar between factors within each data source (e.g., the degree to which the relation between *active learning* use and student *participation* was similar for students, instructors, and observer), we compared the bivariate Pearson correlations. We used Fisher's (1925) z-transformation to adjust for the non-normal distribution of correlation values and then conducted a z-test to determine the two-tailed statistical significance (95% confidence) of the difference between the transformed values (Howell, 2009).

3. Results

A total of 28 instructors attended workshops in May 2019 and completed surveys during Fall 2019; a total of n=780 students from their classrooms participated. A subset of these instructors, n=14, and their students participated in a classroom observation.

3.1. Participant Characteristics

Instructors taught at 10 institutions across the state of Texas, comprised of mostly public and a nearly equal split of 2-year and 4-year institutions. Instructors represented a variety of STEM departments. Most taught first- and second-year students, with class sizes ranging from 15-200 students and a mean and median class size of 48 and 35 students, respectively. Table 1 provides a demographic overview of instructors and an academic overview of their students.

Table 1: Overview of Participant Characteristics

	Instructors	**%**	**Students**	**%**
Gender	*n=28*		*n=780*	
Male	15	53.6	-	-
Female	13	46.4	-	-
Race/Ethnicity				
White	16	57.1	-	-
Asian	6	21.4	-	-
Black	4	14.3	-	-
American Indian or Alaskan Native	1	3.6	-	-
Prefer Not to Answer	1	3.6	-	-
Discipline				
Chemistry	4	14.3	48	6.2
Computer & Information Sciences	3	10.7	93	11.9
Engineering & Engineering Technology	3	10.7	47	6.0
Geosciences	3	10.7	58	7.4
Life Sciences	6	21.4	162	20.8
Mathematical Sciences	6	21.4	278	35.6
Physics & Astronomy	3	10.7	94	12.1

3.2. Statistical Analyses

We present means, standard deviations, and correlations for the eight instructor-reported measures in Table 2, for the eight student-reported measures in Table 3, and for the five observed measures in Table 4. We report between-data source correlations within factors in Table 5 and the relation between factors by data source in Table 6. Our analyses reveal a disconnect between instructor perceptions of their students' responses to active learning (Table 2) and students' self-reported attitudes and behaviors (Table 3), where instructors overestimate student resistance. There is a disconnect between student and instructor perceptions of their classrooms (Table 5). On average, students report they see more value in the activities, feel more positively towards them, and even plan to more highly evaluate the course and instructor at the end of the semester than instructors expect (Table 6).

3.3. Instructor Perceptions

To answer our first research question, we explore instructors' perceptions of their own classrooms. Instructors were asked to report their overall use of active learning and strategies to reduce student resistance while teaching, and to evaluate their students' behavior throughout the class period on five metrics: value, positivity, participation, distraction and evaluation.

Table 2. Correlations, Reliability, Means, and Standard Deviations for Instructor Self-report Factors.

	1	2	3	4	5	6	7	8
1. Active Learning[1]	1.00							
2. Explanation[1]	.54**	1.00						
3. Facilitation[1]	.47*	.81**	1.00					
4. Value	.55**	.68**	.64**	1.00				
5. Positivity	.33	.53**	.54**	.73**	1.00			
6. Participation	.44*	.61**	.60**	.62**	.67**	1.00		
7. Distraction	-.27	-.30	-.35	-.40*	-.38*	-.30	1.00	
8. Evaluation	.51**	.38*	.42*	.53**	.51**	.39*	.04	1.00
N	28	28	28	28	28	28	28	28
Items	5	4	5	3	5	3	3	3
Reliability (α)	.70	.85	.88	.61	.66	.57	.47	.97
Mean	8.50	8.27	8.39	5.68	5.90	5.82	1.75	5.38
SD	1.38	1.77	1.86	0.92	0.78	0.85	0.49	1.13

Notes. * $p < .05$, ** $p < .01$. [1]Indicates a response scale of 1-10. All others are 1-7.

As shown above, on average, instructors' self-reported use of active learning, explanation, and facilitation strategies to reduce student resistance were high at 8.5, 8.27, and 8.39 out of 10, respectively, and all three factors showed strong correlations, between 0.55 and 0.81, with one another. Instructors reported moderate levels of perceived student value, positivity, participation, and evaluation, and lower levels of student distraction, at 5.7, 5.9, 5.8, 5.4, and 1.8 out of 7, respectively.

There is a significant correlation between active learning use and instructor's perceptions of student participation and expected evaluation, at 0.44 and 0.51, respectively. However, instructors did not see a relation between active learning use and students' positivity or their level of distraction. Instructors' use of both explanation and facilitation strategies indicated significant, positive relationships to instructors' perception of students' value, positivity, participation, and evaluation but neither related to students' level of distraction.

3.4. Student Perceptions

Next, to address our second research question, we explore students' perceptions of their instructors' teaching methods and their own responses to these methods. Students were asked to report their instructors' overall use of active learning, explanation strategies and facilitation strategies. Then, students were asked to rate how they responded to the non-lecture activities throughout the class period.

Table 3. Correlations, Reliability, Means, and Standard Deviations for Student Self-report Factors.

	1	2	3	4	5	6	7	8
1. Active Learning[1]	1.00							
2. Explanation	.62**	1.00						
3. Facilitation	.76**	.64**	1.00					
4. Value	.73**	.77**	.71**	1.00				
5. Positivity	.76**	.78**	.72**	.94**	1.00			
6. Participation	.36	.58**	.44*	.34*	.41*	1.00		
7. Distraction	-.35	-.41*	-.35	-.47*	-.52**	-.42*	1.00	
8. Evaluation	.74**	.73**	.55**	.82**	.81**	.42*	-.34	1.00
N	28	28	28	28	28	28	28	28
Items	5	4	5	3	5	3	3	3
Reliability (α)[2]	.89	.86	.80	.90	.81	.74	.70	.91
Mean	8.50	5.95	5.63	5.97	5.71	6.04	2.23	5.92
SD	1.04	0.49	0.70	0.52	0.62	0.43	0.52	0.64

Notes. * $p < .05$, ** $p < .01$. [1]Indicates a response scale of 1-10. All others are 1-7. [2]Reliability was factored with all 780 student participants.

Students indicated that instructors frequently used active learning, at 8.5 out of 10, as well as explanation and facilitation strategies, at 5.95 and 5.63 out of 7. When describing their own response to activities, students report high levels of value, positivity, participation, and evaluation and low levels of distraction, at 5.97, 5.71, 6.04, 5.92, and 2.23 out of 7, respectively. In other words, students report very little resistance to active learning in their classrooms.

Students' report of instructors' active learning use was highly correlated with their self-reported value, positivity, and evaluation, but not with their participation or distraction. Students' report of instructors' use of explanation and facilitation strategies was highly correlated at 0.64, and both related to students' self-reported value, positivity, participation, and evaluation. Distraction only negatively correlated with instructors' use of explanation strategies.

3.5. Observed Behaviors

Half of the classrooms, n=14, in our sample were observed to evaluate instructor and student behavior in class from an objective perspective. As affective responses are not always directly observable, the observation data contains fewer factors than the survey instruments. Here, we examine instructors' use of active learning, explanation, and facilitation strategies, but only participation and distraction at a student-level.

Table 4. Correlations, Means, and Standard Deviations for Observed Factors.

	1	2	3	4	5
1. Active Learning[1]	1.00				
2. Explanation Strategies[2]	.21	1.00			
3. Facilitation Strategies[2]	.08	.66**	1.00		
4. Participation[3]	-.06	.50	.82**	1.00	
5. Distraction[3]	.17	-.24	-.67**	-.87**	1.00
N	14	14	14	14	14
Mean	.81	1.51	2.53	5.80	1.44
SD	.20	1.21	0.97	1.22	0.72

Notes. * $p < .05$, ** $p < .01$. [1]Indicates a scale of 0-1. [2]Indicates a count of occurrences per class period. [3]Indicates a scale of 1-7.

Fewer significant correlations were present in the observed data, due largely to the smaller sample size and the less granular observation data. Observed use of explanation and facilitation strategies to reduce student resistance were correlated at 0.66. Observed use of facilitation strategies positively correlated with observed student participation at 0.82 and negatively correlated with distraction at -0.67. There was a strong but not statistically significant relation between observed explanation strategy use and student participation at 0.50.

3.6. Factor Comparisons across Data Sources

Finally, we begin to address our third research question by examining correlations between our data sources for each factor of interest, as shown in Table 5.

Table 5. Between Data Source Correlations by Factor

	Students Instructors	Students Observer	Instructors Observer
1. Active Learning	.26	$.74^{**}$	.17
2. Explanation	.22	.12	.49
3. Facilitation	$.55^{**}$	.52	$.67^{**}$
4. Value	.24	-	-
5. Positivity	.06	-	-
6. Participation	.15	.01	$.58^{*}$
7. Distraction	.30	-.14	.25
8. Evaluation	-.01	-	-

Notes. * $p < .05$, ** $p < .01$.

The correlations between each of the eight factors across data sources are generally not strong, indicating a disconnect between instructors' perceptions, students' perceptions and observers' reports of these metrics. Only facilitation strategy use showed strong agreement across all three data sources, at 0.55, 0.52 and 0.67, though the correlation between students' and observed data was not statistically significant, likely due to lack of statistical power. There was little agreement between any of the data sources on the use of explanation strategies, though the correlation between instructors' report and observation, at 0.49, was likely not significant due to the small sample size.

For active learning use, there was a strong correlation between students' report and observed measure at 0.74; however, there was little correlation between students' and instructors' report at 0.26, nor instructors' report and observation of active learning use at 0.17. There was a significant correlation between instructors' report and observed student participation at 0.58. While observers echo instructors' report of explanation and facilitation strategy use, as well as levels of student participation, students disagree. There was no significant correlation across data sources for any of the remaining factors – value, positivity, participation, distraction, and evaluation. This indicates there is little correlation between student and instructor reports of any measure of student resistance.

3.7. Factor Comparisons across Data Sources

Finally, we compare correlations between active learning use and the remaining seven factors for each of our three data sources. Our analyses reveal several discrepancies in the pattern of relation between factors.

Table 6. Within Data Source Relations between Factors

		Correlations			Between Group Comparison		
		Instructors	Students	Observer	Instructor Student	Instructor Observer	Student Observer
Active Learning	Explanation	.54**	.62**	.21	-0.43	1.08	1.41
Active Learning	Facilitation	.47*	.76**	.08	-1.72	1.19	2.53*
Active Learning	Value	.55**	.73**	-	-1.10	-	-
Active Learning	Positivity	.33	.76**	-	-2.31*	-	-
Active Learning	Participation	.44*	.36	-.06	0.34	1.47	1.21
Active Learning	Distraction	-.27	-.35	.17	0.31	-1.24	-1.48
Active Learning	Evaluation	.51**	.74**	-	-1.37	-	

Notes. * $p < .05$, ** $p < .01$. Between group comparison reports Fisher's (1925) z.

Although the relation between active learning use and explanation and facilitation strategies was high for students and instructors, there was not a significant correlation between those factors, or others, in the observed data. Lack of statistical significance in the observed data is likely due to the lack of statistical power at n=14.

Students affective and behavioral responses to active learning are largely positive, with high levels of value, positivity and evaluation, at 0.73, 0.76, and 0.74, respectively. Correlations between active learning use and both measures of student affect are statistically significant. Moreover, student reports of participation are moderately, positively correlated at 0.36, and reports of distraction are moderately, negatively correlated with active learning use at -0.35.

However, instructors report a weaker relation between active learning use and students' value and positivity than their students do. Both instructors and students agree that active learning use is negatively correlated with student distraction, at -0.27 and -0.35, and instructors report a statistically significant positive relationship between active learning use and evaluation at 0.51. Yet, when contrasted to students' report of this relationship at 0.74, we see these instructors still underestimate how positively students will respond.

4. Discussion

Instructors' perceptions of student resistance to active learning have significant implications for STEM education, as the literature shows that instructors' concerns about student resistance are a significant barrier to its adoption (Finelli et al., 2013; Froyd et al., 2013; Prince et al., 2013). Broad adoption of active learning in STEM classrooms, with the corresponding improvement in student learning, reduction in failure rates, increase in student motivation and greater retention in STEM programs, would all benefit if this core barrier were reduced or eliminated for instructors. Yet, research shows that merely disseminating research data is insufficient to catalyze adoption of effective instructional methods (Dancy et al., 2016; Hora et al., 2012; Jamieson & Lohmann, 2012; National Research Council, 2012). This is in part because adoption is as much an emotional decision, based on instructors' subjective perceptions of what happens in their classes, as it is an intellectual one.

It is important to highlight that student resistance as a barrier to change hinges directly on instructors' perceptions of their students. If those perceptions are mostly inaccurate, there are significant implications for faculty developers to overcome these inaccuracies. As such, sharing counterintuitive data that illuminates significant gaps between instructors' perceptions of student resistance and students' actual resistance behaviors might provide a first step in reducing instructors' fears and promoting lasting instructional change.

4.1. Student Responses to Active Learning

The low levels of both behavioral and attitudinal student resistance documented here (Table 3) are extremely encouraging. Contrary to instructors' possible concerns about student participation, students responded that they would actively participate and try their hardest to do a good job when being asked to do an activity. Similarly, students generally disagreed that they disengaged from the activity by instead surfing the internet or distracting their classmates, etc. Students generally saw value in the activities and thought that time used for the activities was worthwhile. On average, student responses show that they enjoyed the activities, and further, thought positively about the instructor because of the activities. These high levels of value, engagement and positivity are consistent with prior student-focused literature on active learning in general (Lumpkin et al., 2015), and in STEM specifically (Miller & Metz, 2014; V. Smith & Cardaciotto, 2011).

Perhaps instructors' most consequential fear is their concern about how their use of active learning might lower their end of semester course evaluations, especially among instructors whose tenure, promotion and merit ratings depend heavily on such measures. Here, the results are again encouraging. After being asked to reflect on the class activities, students generally agreed that they would rate the instructor an excellent teacher and that the course was an excellent course.

In addition to the low measures of student resistance reported in this study, the correlations between the use of active learning and student responses was also encouraging. There were positive correlations between active learning use and both positivity and value, suggesting perhaps that the student responses to active learning improve the more they experience and become familiar with it. Moreover, there was a significant and positive correlation between instructors' use of active learning and students' evaluation of the course and instructor.

4.2. Misalignment of Student & Instructor Perceptions

The data cited above speaks to objective measures of student resistance, which were generally low. As mentioned previously, however, instructor choices about adopting specific teaching strategies like active learning are driven not just by objective data but by the instructors' subjective perceptions of what may be happening in their classes. Prior research has noted that instructors not only overestimate their own usage of active learning, but also underestimate students' enjoyment of the activities and the amount of class time they would like to be devoted to active learning (Patrick et al., 2016). In this study we examined whether instructors' perceptions related to student resistance, specifically, are accurate.

Our results suggest that in general, they are not. Table 5 shows a clear pattern of disconnect between instructors' reports and student reports of resistance measures. On all measures of student resistance (value, positivity, participation, distraction and evaluation) there are low correlations between the instructors' perceptions of these resistance measures and the student-reported resistance measures. These results suggest that, on average, instructors are poor judges of student resistance and that they should, therefore, give them less weight in their decision processes and rely more heavily on objective measures of student resistance.

4.3. Implications

There are a number of possible implications of these findings. Here, we highlight the importance of data triangulation to better understand what is actually happening in the classroom. Relying on instructors alone, for instance, leaves interpretation vulnerable to the subjective perspectives of the participants; analyzing data from multiple sources allows researchers to gain a more comprehensive and accurate depiction of classrooms. Further, these findings strengthen the overall argument for adopting active learning and may provoke further research into their generalizability. While empirical data alone does not directly drive instructional change, it should remain a key element of a broader strategy to promote adoption of evidence-based teaching practices in STEM classrooms.

For faculty developers, the results provide some initial ammunition for reducing instructors' concerns about student resistance. Our findings of very low student resistance, in combination with previous research on effective strategies for reducing student (Finelli et al., 2018), provide promising tools for promoting lasting change. Interventions focused on improving instruction may need to shift not only instructor behavior, but also their mental representations of students' responses. Faculty developers should emphasize that instructors should rely more on data and less on their subjective perceptions of resistance.

For instructors, there are similar implications. The data supporting the benefits of active learning are extensive and compelling. Instructors' concerns about student resistance as a barrier to adoption are understandable, but the data presented here suggests that this fear might be reinforced by a number of misconceptions about levels of student resistance found in most classes.

5. Conclusions

Adopting evidence-based teaching practices, such as active learning, has proven to increase student learning, engagement, and interest in STEM and subsequently, the number and diversity of STEM graduates. Despite these compelling findings, the translation of educational research to classrooms has been slow, in part due to instructors' concerns about student resistance.

Analyses of matched observations (n=14) and survey datasets (n=28, n=780) reveal a disconnect between instructor perceptions of their students' responses to active learning and students' self-reported attitudes and behaviors, where instructors overestimate resistance. On average, students report they see value in the activities, enjoy them, and even plan to highly evaluate the course and instructor at the end of the semester. Overall, these results suggest that instructor reported barriers to adopting active learning, such as concerns about student resistance, stand in stark contrast to students' opinions and behaviors. We hope these results can be operationalized to promote instructor change and translate the many benefits of these techniques into as many STEM classrooms as possible.

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Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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Table 1: Overview of Participant Characteristics

	Instructors	%	Students	%
Gender	*n=28*		*n=780*	
Male	15	53.6	-	-
Female	13	46.4	-	-
Race/Ethnicity				
White	16	57.1	-	-
Asian	6	21.4	-	-
Black	4	14.3	-	-
American Indian or Alaskan Native	1	3.6	-	-
Prefer Not to Answer	1	3.6	-	-
Discipline				
Chemistry	4	14.3	48	6.2
Computer & Information Sciences	3	10.7	93	11.9
Engineering & Engineering Technology	3	10.7	47	6.0
Geosciences	3	10.7	58	7.4
Life Sciences	6	21.4	162	20.8
Mathematical Sciences	6	21.4	278	35.6
Physics & Astronomy	3	10.7	94	12.1

Table 2. Correlations, Reliability, Means, and Standard Deviations for Instructor Self-report Factors.

	1	2	3	4	5	6	7	8
1. Active Learning[1]	1.00							
2. Explanation[1]	.54**	1.00						
3. Facilitation[1]	.47*	.81**	1.00					
4. Value	.55**	.68**	.64**	1.00				
5. Positivity	.33	.53**	.54**	.73**	1.00			
6. Participation	.44*	.61**	.60**	.62**	.67**	1.00		
7. Distraction	-.27	-.30	-.35	-.40*	-.38*	-.30	1.00	
8. Evaluation	.51**	.38*	.42*	.53**	.51**	.39*	.04	1.00
N	28	28	28	28	28	28	28	28
Items	5	4	5	3	5	3	3	3
Reliability (α)	.70	.85	.88	.61	.66	.57	.47	.97
Mean	8.50	8.27	8.39	5.68	5.90	5.82	1.75	5.38
SD	1.38	1.77	1.86	0.92	0.78	0.85	0.49	1.13

Notes. * $p < .05$, ** $p < .01$. [1]Indicates a response scale of 1-10. All others are 1-7.

Table 3. Correlations, Reliability, Means, and Standard Deviations for Student Self-report Factors.

	1	2	3	4	5	6	7	8
1. Active Learning[1]	1.00							
2. Explanation	.62**	1.00						
3. Facilitation	.76**	.64**	1.00					
4. Value	.73**	.77**	.71**	1.00				
5. Positivity	.76**	.78**	.72**	.94**	1.00			
6. Participation	.36	.58**	.44*	.34*	.41*	1.00		
7. Distraction	-.35	-.41*	-.35	-.47*	-.52**	-.42*	1.00	
8. Evaluation	.74**	.73**	.55**	.82**	.81**	.42*	-.34	1.00
N	28	28	28	28	28	28	28	28
Items	5	4	5	3	5	3	3	3
Reliability (α)[2]	.89	.86	.80	.90	.81	.74	.70	.91
Mean	8.50	5.95	5.63	5.97	5.71	6.04	2.23	5.92
SD	1.04	0.49	0.70	0.52	0.62	0.43	0.52	0.64

Notes. * $p < .05$, ** $p < .01$. [1]Indicates a response scale of 1-10. All others are 1-7. [2]Reliability was factored with all 780 student participants.

Table 4. Correlations, Means, and Standard Deviations for Observed Factors.

	1	2	3	4	5
1. Active Learning[1]	1.00				
2. Explanation Strategies[2]	.21	1.00			
3. Facilitation Strategies[2]	.08	.66**	1.00		
4. Participation[3]	-.06	.50	.82**	1.00	
5. Distraction[3]	.17	-.24	-.67**	-.87**	1.00
N	14	14	14	14	14
Mean	.81	1.51	2.53	5.80	1.44
SD	.20	1.21	0.97	1.22	0.72

Notes. * $p < .05$, ** $p < .01$. [1]Indicates a scale of 0-1. [2]Indicates a count of occurrences per class period. [3]Indicates a scale of 1-7.

Table 7. Between Data Source Correlations by Factor

	Students Instructors	Students Observer	Instructors Observer
1. Active Learning	.26	.74**	.17
2. Explanation	.22	.12	.49
3. Facilitation	.55**	.52	.67**
4. Value	.24	-	-
5. Positivity	.06	-	-
6. Participation	.15	.01	.58*
7. Distraction	.30	-.14	.25
8. Evaluation	-.01	-	-

Notes. * $p < .05$, ** $p < .01$.

Table 8. Within Data Source Relations between Factors

		Correlations			Between Group Comparison		
		Instructors	Students	Observer	Instructor Student	Instructor Observer	Student Observer
Active Learning	Explanation	.54**	.62**	.21	-0.43	1.08	1.41
Active Learning	Facilitation	.47*	.76**	.08	-1.72	1.19	2.53*
Active Learning	Value	.55**	.73**	-	-1.10	-	-
Active Learning	Positivity	.33	.76**	-	-2.31*	-	-
Active Learning	Participation	.44*	.36	-.06	0.34	1.47	1.21
Active Learning	Distraction	-.27	-.35	.17	0.31	-1.24	-1.48
Active Learning	Evaluation	.51**	.74**	-	-1.37	-	

Notes. * $p < .05$, ** $p < .01$. Between group comparison reports Fisher's (1925) z.