

Development of an Observation Protocol to Study Undergraduate Engineering Student Resistance to Active Learning*

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Student resistance is often cited as a major barrier to instructors' use of active learning, but there are few research-based strategies for reducing this barrier. In this paper, we describe the first phase of our research—the development and validation of a classroom observation protocol to assess student responses to instructors' use of active learning. This protocol, which draws upon other published observation protocols, allows researchers to capture data about instructors' use of and students' responses to active learning. We also present findings from four first and second year engineering courses at two institutions that demonstrate the variety of ways engineering students resist active learning and strategies that engineering instructors have employed to reduce student resistance.

Keywords: active learning; instructional strategies; observation; student resistance

1. Introduction

Researchers have extensively documented the effectiveness of active learning in improving student learning when compared to traditional lecture-based instructional strategies [1–3]. In spite of the ample evidence of effectiveness, the translation of research to actual classroom practice has been slow [4–9]. Even when instructors are convinced of the efficacy of active learning techniques, reported barriers to use include instructor concerns about preparation time, class time constraints, and student resistance [10–14]. While both preparation and class time have been previously addressed in the literature [15–18], relatively little prior work has investigated the barrier of student resistance. This paper describes the beginning of a larger project designed to fill this gap. Our overarching research

question asks: what factors, including instructor strategies, influence student resistance to nontraditional teaching, and what specific strategies can instructors employ to significantly reduce student resistance? The development and validation of the observation protocol described here is an early step towards identifying instructor strategies and specific student reactions on which to focus future investigations of student resistance.

Students can respond in both positive and negative ways to faculty's use of active learning, but here we specifically study negative student reactions, and we use the term *student resistance* to describe negative student responses to new instructional methods. Students may resist the introduction of active learning methods because these methods tend to: require more work on the part of the student, cause anxiety about students' ability to succeed in a

new environment, and set expectations that students are not yet prepared to meet [19–23]. Weimer [23] characterizes student resistance into three basic levels: (1) passive, non-verbal, (2) partial compliance, and (3) open resistance. Students engaged in passive, nonverbal resistance tend to participate less in class activities; for example, they may sit quietly when asked to discuss with nearby students. In partial compliance, students complete activities without enthusiasm and at the lowest possible level. Open resistance occurs when students actively complain about the teaching methods, often in front of—and with the intent of rallying—their classmates.

Researchers and instructional development experts [21, 24–26] have offered recommendations to reduce student resistance to active learning, but these recommendations have been primarily anecdotal. Before we can study student resistance in a more systematic way, we first need to know more about student resistance. Researchers have recommended several factors that should be taken into consideration when studying student resistance. Alpert [20] suggested that it is important to distinguish repeatedly occurring instances of widespread student resistance from temporary instances tied to a particular incident. Åkerlind and Trevitt [19] noted that it is critical to anticipate and handle student resistance in a systematic manner. In terms of assessment and research, Seidel and Tanner [27] recommend systematically collecting classroom evidence of the proportion of students exhibiting resistance and investigating discipline-specific characteristics of student resistance.

In order to gain understanding of student resistance to active learning specific to engineering, we decided to systematically collect empirical evidence by observing active learning-based engineering classrooms. Such observational data allows us to capture specific details of classroom events related to student learning [28]. Observations are advantageous in scenarios where there is little prior knowledge about the phenomenon under study as they allow collection of unforeseen data [29]. In addition, observations allow detailed documentation of events that may go unnoticed among the participants [30]. Furthermore, they allow the researcher to record data that the participants may not be willing to discuss in interviews [30, 31], which may be the case for students resisting or instructors unsuccessfully implementing active learning.

2. Development of the observation protocol

Several protocols have been previously developed to study different attributes that contribute to instructional effectiveness. Our first step in developing an

observation protocol for student resistance was to examine existing classroom observation protocols for items or approaches that could be adopted or adapted to study student resistance. Characteristics of these protocols are summarized in Table 1.

2.1 Existing protocols

The Reformed Teaching Observation Protocol (RTOP), developed by Sawada, Piburn, Judson, Turley, Falconer, Benford and Bloom [32], has been widely used in K-12 education research, particularly by researchers interested in active learning practices [33–35]. The 25-item observation tool allows quantitative measurement of the degree to which active learning has been incorporated in practice. The 25 items were divided into three categories: (1) Lesson Design and Implementation, (2) Content and (3) Classroom Culture. The Classroom Culture items were further categorized into Communicative Interactions and Student/Teacher relationships. Guided by their primary question, “How would you know if a mathematics or science classroom was reformed?”, the protocol focuses primarily on the instructor rather than the students. The focus on the instructor and K-12 settings limits the applicability of this protocol to a study of undergraduate student resistance.

Wakington et al. [38] developed the UTeach Observation Protocol (UTOP) to evaluate mathematics and science teachers from the UTeach teacher preparation program. The researchers motivated the need for this protocol by arguing that the RTOP lays little emphasis on the accuracy and depth of lesson content. The UTOP included 32 classroom indicators categorized into four sections: Classroom Environment, Lesson Structure, Implementation and Math/Science Content. This protocol also focuses on K-12 and may have limited use in undergraduate classrooms.

Specific to postsecondary classrooms, Wainwright, Flick and Morrell [36] developed the Oregon Collaborative for Excellence in the Preparation of Teachers Classroom Observation Protocol (OTOP). Arguing against the appropriateness of directly using observation tools developed for K-12 classrooms (RTOP) in college level studies, the authors developed the protocol to document the influence of instructors’ participation in teacher preparation programs on their instructional design and practice. In addition, the researchers asserted that “observations of teaching should . . . include not just teacher actions, but also student behaviors” (p. 27). Unlike RTOP where the primary focus was on the instructor, OTOP placed equal emphasis on both teacher and student behaviors. However, the protocol did not address student resistance in detail.

Following a similar student centric approach,

Hora and Ferrare [37] designed the Teaching Dimension Observation Protocol (TDOP) to capture the interaction between students, instructors and other artifacts in an undergraduate classroom. Although TDOP places equal emphasis on both instructor and student, the coding rules developed for the cognitive engagement section do not fully capture student engagement. For example, the code representing “connect to real world” was applied when “the instructor linked the course material to events . . . associated with popular culture or the state or city where the institution was located through anecdotes or extended illustrations”. Similarly, the “understanding problem solving” code was applied when “instructors verbally directed students to participate in a computation or other problem solving activity”. In other words, although the TDOP brings new emphasis to student engagement, the focus is still through ways the instructor seeks to engage students rather than the students’ reaction.

Smith et. al. [40] developed The Classroom Observation Protocol for Undergraduate STEM (COPUS) to characterize the use of active learning in college classrooms. Being an adaptation of TDOP, the COPUS protocol placed equal emphasis on students and the instructor. The protocol used codes (Listening to Instructor/Taking Notes (L), Student asks Questions (SQ), Presentation by students (SP), etc.) to report what the instructor and the students were doing during the class session. However, the protocol focused on capturing positive student reactions rather than passive or negative reactions that would signify student resistance.

In an engineering education focused example, Harris and Cox [28] described the development of an observation protocol, the “VaNTH Observation System,” designed to quantitatively indicate the

differences in teaching and learning experiences in a biomedical engineering classroom. Guided by the How People Learn (HPL) theory, the researchers utilized the proposed four-part observation system to capture the instructional differences between HPL and traditional classrooms. The four parts of the system include: (1) Classroom Interaction Observation, (2) Student Engagement Observation, (3) Narrative Notes, and (4) Global Ratings. The Student Engagement Observation section specifically caters to students’ desired and undesired behaviors in a classroom. The researchers modified their HPL based K-12 model to make the protocol appropriate for college level observation. Specifically, a new category of “off-task with media” was added to address the undesirable use of personal computers in the classroom. Also, student engagement was refined from “yes” or “no” to “possibly engaged” and “definitely engaged”. Observers relied on the extent of student note-taking and listening to determine whether students were possibly or definitely engaged. Thus, the protocol was able to capture student behavior in a college level classroom. However, we argue that since note-taking and passive listening may indicate student disengagement more than engagement in an active learning-based classroom, the protocol is not appropriate for observing student resistance.

In summary, although the existing observation protocols cater to nontraditional teaching practices, they cannot be directly applied for observing student resistance to active learning in engineering classrooms because: (a) the protocols have been designed for K-12 classrooms [e.g. 32, 38]; (b) the protocols focus more on instructor than student behavior [e.g. 37, 39]; or (c) the protocol does not sufficiently capture student resistance [e.g. 28, 36, 40].

Table 1. Summary Characteristics of Previous Classroom Observation Protocols

Protocol	Level (K-12, UG)	Student/instructor focus	Detail about student reactions	Key reference	STEM application references
RTOP	K-12	Primarily on instructor	Student communicative interactions	Hora and Ferrare [37]	MacIsaac and Falconer [33], Judson and Lawson [34], Adamson, Banks [35]
UTOP	K-12	Instructor only	None	Walkington et al. [41]	Walkington and Marder [41]
OTOP	UG	Both student and instructor	Student Discourse and collaboration	Wainwright, Flick [36]	Wainwright, Morrell, Flick and Schepige [42]
TDOP	UG	Both student and instructor	Limited focus on student engagement	Hora and Ferrare [37]	Hora, Ferrare [9]
COPUS	UG	Both student and instructor	Only positive student reactions	Smith et al. [40]	Smith, Jones [40]
VOS	UG	Primarily on instructor	Only note-taking and listening as indicators of student engagement	Harris and Cox [28]	Cox and Cordray [43]

2.2 Our observation protocol

We developed our classroom observation protocol by first reflecting on our experience with other protocols. One of the authors had previously used the TDOP [37] to collect a holistic assessment of student/instructor interaction in the engineering classroom [44], but because the current project was focused on student resistance, the classroom observation protocol needed to address specific instances of active learning and instructor strategies to reduce student resistance. Thus, we integrated elements from the TDOP as well as several other observation protocols [32, 38] with items designed to align with survey instruments that we were considering for other aspects of our research [45]. Our protocol is broad and open ended because there is limited literature about student resistance. The items are designed to be completed for every instance of active learning. The protocol includes details about the active learning activity, estimates of student engagement levels, and items to capture ways the instructor addresses student questions and concerns about the activity (including recommended strategies to reduce student resistance). Three authors drafted an initial protocol with these ideas in mind. We also conducted focus groups with engineering students to understand their reactions to active learning [46].

We conducted pilot observations [47], then we revised and clarified various components of our protocol and performed additional analyses, validation, and reliability procedures. Additionally, we updated the protocol in the following ways. We observed variation in student resistance depending upon the type of material (New/Review) introduced in the active learning activity and whether active learning was implemented as an individual activity or group work. To capture this in the protocol, we added items to describe “Covered Course Topic (New Material/Review)” and differentiate “group” and “individual” assignments. In addition, we revised the operational definition of high instructor participation to include the instructors’ ability to monitor students’ progress by checking on their work and by clarifying doubts.

The final version of our protocol consists of two pages on which the observer records the starting and ending time of each active learning episode and documents several other important aspects of it:

- *Type of material.* The observer reports the difficulty level (difficult/easy) and newness (new/review) of the material covered in the active learning instance. In addition, the observer documents the cues offered by the instructor indicating the difficulty level and newness of the material.
- *Type of active learning used by the instructor.* The

observer may either choose from one of several listed common types of active learning or specify it under “other.” Specifically, the observer indicates whether the active learning type was implemented as an individual activity or was assigned as group work. There is also an open-ended section for additional comments about the type of active learning.

- *The degree of instructor participation during the activity.* The observer estimates the overall degree of instructor participation by choosing from either high (instructor moves around the room, actively engages with students, monitors student progress, clarifies doubts), medium (instructor only responds to student questions without monitoring student progress, intervening in their work, etc.), or low (instructor does not interact with students during the activity).
- *The way the instructor describes the activity.* The observer indicates whether the instructor engages in a particular strategy (e.g., explaining what students are expected to do) and, if so, provides a written description of the strategy. Additionally, there is an open-ended section to document any other ways the instructor introduces the activity.
- *The degree of student engagement during the activity.* The observer records levels of student engagement by providing the approximate level of student engagement, recorded as approximate percentages of the class engaged. The observer may choose from high (more than 90% engaged), mixed (50%–90% engaged), and low (less than 50% engaged) levels of engagement. The observer also records the evidence of engagement (for example, a student’s posture) or lack of engagement (for example, off topic internet browsing) in the open ended description section.
- *The way the students resist during the activity.* The observer documents the specifics of student resistance to the active learning activity and estimates the approximate percentage of students demonstrating partial compliance; passive, non-verbal resistance; or open resistance. Additionally, the form provides an open-ended space to describe, in detail, evidence of observed student resistance (i.e., the specific behaviors).

In addition to the daily observation protocol, we also designed a first-day protocol to document activities occurring on the first day of class, including the ways by which the instructor introduces the active learning practices to be used throughout the semester, how the active learning exercises will be graded, and general expectations for participation in active learning. The most recent versions of both protocols are included in the Appendix.

2.3 Reliability and validity

Inter-rater reliability between the two observers at the two institutions was established using the recorded videotapes of engineering class sessions at institution A. Two observers viewed the video recording of class sessions, completed the protocol, discussed their results with each other, and clarified discrepancies. Overall, there was a high level of agreement with respect to the number of active learning instances and whether specific students captured on the video were engaged or disengaged. We plan to incorporate this reliability procedure into a training program for new observers to ensure consistency in the application of the protocol.

To establish validity of the observation protocol, we conducted focus groups with engineering students at two sites. One of the sites, Institution A, included a total of 6 participants recruited from the two observed classes. The other site was an undergraduate teaching focused institution with a total of 16 participating undergraduate engineering students (at which we did not conduct classroom observations). Our focus groups included questions to inquire about students' resistive behaviors to active learning. Due to IRB restrictions, we were not able to show video recordings of our observed classes to students. However, we presented open access images and videos of students sitting in a classroom. We asked focus group participants to identify the individuals who they thought were engaged or disengaged and to explain why. Students provided additional insight into our interpretation of body language as it relates to student resistance. Finally, to further validate our observation protocol, experts reviewed it, and we incorporated their feedback into the final protocol.

3. Methodology

Over the course of spring semester 2014, two researchers observed four large introductory engineering courses (ranging in size from 70–150) at two large public research universities. At Institution A,

we observed every class session of two courses (Course 1 and Course 2) for the first and the final three weeks of the semester. At Institution B, we observed every class session of two courses (Course 3 and Course 4) for the entire semester. Course 1 was a first-year class, while the other three courses were sophomore level. Additional details are listed in Table 2.

Course 1 was held in a large, lecture style auditorium with fixed seating, allowing little space for the instructor to move around the room. Its broad learning objectives were to develop programming skills and understanding of algorithms. The active learning activities asked students to work on programming problems in pairs or triads. Course 2 also had fixed seating, but it was a smaller, lecture style classroom, which allowed the instructor to move freely around the room. Its learning objectives were to teach the planar kinematics of rigid bodies, including introducing concepts on kinetic energy and developing solution strategies for mechanical vibration problems. The active learning activities used in the course allowed students to have hands-on opportunities to work as individuals and in teams on common problems that they would experience as mechanical engineers in the field.

Similar to Course 1, Course 3's learning objectives included programming and was held in a large, lecture style classroom with fixed seating. The active learning activities involved students working on programming problems to simulate chemical engineering processes. On the other hand, Course 4 was held in a large classroom with cluster-style seating which allowed the instructor to move freely and also facilitated the use of group-based active learning in the classroom. Its learning objectives included developing an understanding of computer organization and architecture, identification of the elements of modern instructions sets and explaining their impact on processor design. The active learning activities involved students discussing conceptual questions and writing instruction sets to perform various memory and computer processor operations. Lastly, contrary to other three courses,

Table 2. Details of the 4 engineering courses we observed

Course	Institution	Academic level	Enrollment/ Seating Capacity	Seating arrangement	Frequency of observations
1. Introduction to Computer Programming	A	First-Year	150	Auditorium-style, low instructor mobility	First and final three weeks
2. Introduction to Dynamics	A	Sophomore	71	Auditorium-style, high instructor mobility	First and final three weeks
3. Chemical Engineering Simulations	B	Sophomore	115	Auditorium-style, low instructor mobility	Entire Semester
4. Computer Organization and Architecture	B	Sophomore	88	Cluster-style, high instructor mobility	Entire Semester

Course 3 had allocated a grade for participation in the active learning exercises.

4. Findings

In Course 1, we observed the instructor using just one type of active learning: asking the students to work in pairs on sample problems. The instructor asked the students to indicate their pair's answers by using hand gestures (e.g., raising their hands in the air or crossing their arms to indicate a particular choice).

The instructor introduced activities by explaining the sample problem. Apart from a few occasions where the instructor responded to questions asked by students sitting at the front of the room, we observed relatively low rates of instructor participation. The instructor rarely circulated around the classroom to interact with students, primarily because the classroom configuration limited that.

Overall, we observed low student participation during the active learning exercises. In addition, we observed a decline in student participation as the semester progressed. Approximately 50–70% of students in attendance participated in the activities at the beginning of the semester, while only 20–30% participated by the end of the course. The students demonstrated resistance by participating in off-task activities such as accessing social media on cell phones and laptops, sleeping during class, or talking about non-course topics with each other.

In Course 2, the instructor used multiple active learning techniques within one single problem. For example, on one such occasion, the instructor initially asked the students to work individually and share their solutions with their neighbors for the first part of the problem. For the second part, he asked the students to work in pairs and share their findings with the whole class.

The instructor introduced the activity in a similar way to the Course 1 instructor, i.e., with little explanation of the purpose. However, we observed variation in instructor participation based on the students' response. Specifically, the instructor ventured around the classroom to address questions and check on student progress when he noticed widespread confusion or lack of participation among students. The classroom layout facilitated the instructor's movement around the classroom, allowing the instructor to remain highly engaged during each activity when necessary.

In general, we observed a high level of student participation in these instances of active learning. However, we did occasionally observe low participation when the instructor asked the students to work in small groups instead of working individually. Students demonstrated resistance mostly in the

form of non-participation (i.e., students would appear to be "in thought" rather than actively participating in the problem) and rarely resisted by participating in off-task work (e.g., texting on cell phones, working on laptops, sleeping). We observed that the instructor often approached students exhibiting resistance and encouraged them by using non-confrontational approaches. For example, on several occasions, the instructor casually approached students who were not participating and inquired about their progress with the assigned problem. We observed increases in those students' participation throughout the rest of the activity as well as during future activities.

In Course 3, the instructor used only one type of active learning: asking students to work on a programming problem and submit their results electronically. Two different web based submission tools were used by the instructor. The first tool had a multiple-choice question format, while the second tool was more open ended and allowed students to submit their complete computer programs. In spite of encouragement from the instructor to work with their peers, we primarily observed students engaging individually in the active learning exercises.

We observed the instructor introducing active learning primarily by explaining the task. However, the instructor solicited feedback and explained the purpose of active learning in two separate instances. In the fifth week, the instructor asked students whether the activities helped them learn, and in the twelfth week (of 15 weeks) he explained how engineers in industry use similar simulation approaches to solve problems and analyze data. The instructor consistently moved around the classroom to answer questions during the activity and often approached students who were not participating. However, the auditorium-style seating arrangement restricted the instructor to focus only on the students sitting at the end of a row or in the front of the room.

We observed students demonstrating resistance primarily through non-participation or engagement in off-task activities. In addition, we observed resistant students copying their neighbors' answers during multiple-choice submissions. Overall, we observed an increase in student participation from 60–70% at the beginning of the term to approximately 90% towards the end. This could at least partially be attributed to the utilization of the open ended simulation tool as the mode for submission in the latter half of the semester, making it less tempting for students to copy their neighbors' solutions.

In Course 4, we observed the instructor using group-based active learning, requiring the students to work in small groups to either discuss a concept or to solve a problem. The instructor clearly explained the activity and regularly emphasized

expectations from students during the active learning session. Although the instructor consistently demonstrated a high degree of participation by circulating around the room and answering students' questions, we observed no discussion about the purpose of the activity (i.e., improved learning).

As in the other courses, the students in this course resisted by not participating and by engaging in off-task activities. We observed varying levels of student resistance in response to the type of active learning introduced.

Particularly, students resisted group activities, and they demonstrated higher levels of participation during group discussion than during group problem-solving which typically called for longer interaction with peers. However, the instructor was able to foster higher levels of participation by calling on the resisting students for answers to the problem.

In addition, lower participation was observed in some instances in which complex topics were being taught; however, the instructor handled the resistance by re-introducing the complex problem as multiple short active learning activities. The summary of findings for the four courses are listed in Table 3.

5. Discussion

This observation protocol is designed to capture instructor and student engagement during active learning instances introduced into the college classroom. In addition, the protocol collects targeted data related to the degree, type and evolution of student resistance during these instances. Since the

protocol also captures a number of environmental factors (class size, seating arrangement, etc.), researchers can attempt to relate student resistance (by type) with a number of possible factors that potentially promote student engagement or resistance. While existing observation protocols capture some of this information, no existing protocol provides such a holistic and targeted instrument to study student resistance to active learning methods in the college classroom.

The initial data presented here yields some interesting observations about student resistance to active learning. Although the findings are preliminary, some early patterns are worth noting here.

1. Consistent with the concerns of many instructors, large class sizes and physical limitations of the classroom itself may offer significant challenges to instructors trying to promote high levels of student engagement. While active learning has been successfully implemented in very large classes [48], it has been found that the education benefits generally decrease slightly with increasing class size [2]. Early observations collected in this study are consistent with this finding, with the largest classroom (Course 1) exhibiting the lowest levels of student engagement. The student engagement levels in this course also decreased rather than increased over the course of the semester. While students were not actively resistant, we did observe that a majority of students in this largest class exhibited passive resistance by the latter part of the semester.

Table 3. Summary of findings

Course	Type of Active Learning	Instructor Participation	Type of Student Resistance	Variation in Student Engagement
1. Introduction to Computer Programming	Students work in pairs on sample problems	Low	Open resistance (non-participation and off-task activities)	Decline in engagement as the semester progressed
2. Introduction to Dynamics	Students to work individually and/or in pairs on sample problems.	Medium	Open resistance (non-participation)	Low engagement when asked the students to work in small groups
3. Chemical Engineering Simulations	Students work on a programming problem and submit their results electronically	High	Open resistance (non-participation and off-task activities) Partial compliance (Copying neighbor's answers)	Increased engagement with the use of open-ended submission tool than multiple choice
4. Computer Organization and Architecture	Students work in small groups to either discuss a concept or to solve a problem	High	Open resistance (non-participation and off-task activities)	Low engagement to group activities when compared to individual Low engagement in problem solving activities when compared to discussion

2. Instructor involvement also plays a significant role. Course 1 had the lowest level of instructor involvement during the activities, in part because the large class size and seating configuration restricted some types of instructor involvement. Courses in which the instructor was more involved (Courses 2, 3 and 4) all exhibited higher degrees of student engagement and conversely, lower levels of passive resistance. In particular, instructors who approached passive student groups and gently encouraged students to participate in the activity saw more positive results, not just for that particular activity but in subsequent course activities. This type of instructor involvement has been recommended by previous authors [15], but without documented observations verifying the effectiveness of the technique.
 3. Another factor that may influence the degree and type of student resistance is the way in which the instructor introduces the activity. In Course 1, the instructor explained the example problem but did not describe the purpose of the class activity or the benefits of engaging in the activity to the students. In Course 2, which had some of the highest levels of student engagement, the instructor introduced the problems in the same way as Course 1 but followed up differently. In Course 3 the instructor at least occasionally explained the purpose of the activity and linked the activities to what students would do in industry, and in Course 4, the instructor explained the purpose of the activity more clearly. Both Course 2 and 4 had high levels of student engagement.
 4. Group activities in these early studies seem to promote more resistance than individual student activities. Course 1, which had the highest levels of passive resistance, relied exclusively on pairing students for class activities. Course 2, which had some of the highest levels of student engagement, used a variety of student activities, many of which began initially by having students work individually. (Such “think-pair-share” activities naturally engage a broader range of learning styles, which may have something to do with their success [49].) Students in Course 3 frequently ignored the instructor’s suggestion to pair and instead completed activities individually, and we observed a similar trend in Course 4, with higher levels of student resistance being clearly linked to group activities. This initial pattern between passive resistance and group activities is worth exploring further. While the educational benefits of group work are well documented [3], it will be important to know if these types of group activities generate significantly higher levels of student resistance. If true, this may suggest that instructors adopt specific strategies to promote higher levels of student engagement during group activities.
 5. A variety of activities may also contribute to lower levels of student resistance. Although other factors including class size, classroom layout, group vs. individual activities, and instructor behavior may explain the differences, we observed the highest level of student engagement in Course 2 which had the most variety in activities. We also observed the instructor in Course 4 react to student resistance in real time by varying activities to successfully engage more students.
 6. Finally, our observations provide preliminary information on the type of student resistance most likely to be found in engineering classrooms. By far, the most prevalent type of resistance found was passive resistance—students simply not participating or engaging in off-task activities. There were no observations of open student resistance in these early observations, suggesting that such types of student resistance, while serious and disruptive when they occur, may be rare in undergraduate engineering classes.
- In summary, consistent with existing research several factors influence the level of student engagement—class size [2], instructor involvement [49] and type of active learning [3]. Our study provides evidence in support of strategies to reduce student resistance that have been mentioned in the literature but have not been empirically tested. Particularly, we observed the instructor encouraging passive students through non-confrontational approaches to be effective. In addition, we observed that the use of a variety of active learning techniques and introduction of the activity by explaining its purpose was beneficial in fostering high levels of engagement. Although our study provided empirical support for some instructor strategies, further research should be conducted in finding additional strategies in relation with the factors influencing student engagement (class size, type of active learning, etc).

6. Conclusion and future work

Our overarching research question asks: what factors, including instructor strategies, influence student resistance to nontraditional teaching, and what specific strategies can instructors employ to significantly reduce student resistance? We carefully developed this observation protocol as a first step towards identifying instructor strategies and speci-

fic student reactions on which to focus future student and instructor surveys. The next phase of our research involves piloting student and instructor surveys using observations to triangulate student and instructor reports of how active learning methods were presented to students. Observation data will help resolve discrepancies when instructors and students report different perceptions and events in their surveys. The final, full-scale study design of 20 introductory engineering courses includes quantitative data collected through student and instructor surveys and qualitative data from end-of-course interviews with instructors. Observations are an approach not often used in engineering education research, perhaps because they are very labor intensive, but for this project exploring the previously unstudied area of student resistance, observations have already been invaluable in uncovering the effects of student and instructor behaviors, developing a broad understanding of student resistance, and for triangulating and validating other instruments.

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Appendix 1: First Day of Class Observation Form

Classroom Observation Form

Please complete page for *The First Day of Class*

Course ID (NC/BU/UM, Course: ME438, 1 = fall, 2 = winter or spring, 3 = summer, calendar year): _____

Instructor: _____

Course Number and Name: _____ Term & Year: _____

Institution: _____ Date of observation (first day of class): _____

Course official start and end time: _____ Days of week: _____ Name of observer: _____

Course Enrollment: _____

Describe the classroom layout and seating arrangement

List all of the active learning modes or activities mentioned by the instructor that are to take place during the term

1. _____
2. _____
3. _____

How does the instructor introduce active learning?	Check if yes	How if at all did the students react?
Does the instructor clearly explain what students are expected to do and answer questions?		
Does the instructor give students feedback about their learning or their grade?		
Does the instructor clearly explain how the new activities will be graded and how they will affect a student's grade?		
Does the instructor solicit student feedback ?		
Other		

If there are any instances of Active Learning on First Day of Class, Please Use the other form.

Please attach a copy of the course syllabus to this form.

Appendix 2: Observation Form

Classroom Observation Form

Please complete this form for *EACH instance of active learning* the instructor introduces

Every time the instructor asks students to perform a particular task (talk to your neighbor, work on this problem), that is a new instance of active learning. Therefore, a complex problem may include several instances of active learning.

Course identifier: _____

Date of observation: _____

Name of observer: _____

Class attendance (# students present): _____

Start time of the activity: _____ End time of the activity: _____

Type of material: [] Difficult [] Easy [] New [] Review

What cues (if any) does the instructor offer on the difficulty or newness of the problem/material?

1. Type of active learning

- Discussion
 - Group
 - Individual
- Problem Solving Task
 - Group
 - Individual
- Think-pair-share
- Student presentations
- Other

Comments:

2. Degree of faculty participation

High participation: Instructor actively engages students during the exercise, circulating around the room, looking over students work, monitoring student progress, clarifying doubts etc.

Medium participation: Instructor only responds to students' questions without monitoring student progress, intervening in their work, etc.

Low participation: Instructor does not interact with students during activity.

Comments:

3. Instructor introduction of and response during active learning

	Check if yes	Describe
Does the instructor clearly explain what students are expected to do and answer questions?		
Does the instructor give students feedback about their learning?		
Does the instructor solicit student responses during the activity?		
Does the instructor encourage student engagement through his/her demeanor?		
Does the instructor use strategies to reduce student resistance ?		
Does the instructor do other things worth noting ?		

4. Student response during active learning:

a. How would you characterize the *level of engagement* in this class (e.g., what percent of the class exhibits engaged posture, is directly engaged in task, invests high quality time and effort to the activity, asks insightful questions)

- High engagement: More than 90% of class is engaged
 Mixed engagement: 50% to 90% engaged
 Low engagement: More than half the class is off-task (i.e., web surfing, texting, chatting, etc.)

b. List the approximate percentage of the class that exhibits the each type of resistance:

	Approx percent	Describe
Open resistance—voicing objections to activity during class (e.g., “others teachers don’t make us do this” or “I don’t have time for group work outside of my class schedule”)		
Partial compliance—doing the activity very quickly with minimal effort, little to no participation in groups or class discussions, concerns about what the instructor “wants them to do”		
Passive, non-verbal resistance—refusal to participate, pretend to comply, negative body/facial language, chatting about everything but the task in groups		
Other		

5. Did students seem resistant to the activity, and if so, did you observe the instructor doing anything that might have resulted in that resistance?

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