Disruption in Large Classes during Active Learning Sessions

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Disruption in Large Classes during Active Learning with Classroom Response Systems

Abstract

Large class sizes are increasingly common in mechanical engineering undergraduate courses due to increased enrollments of undergraduate students with a disproportional investment to faculty numbers. Simultaneously, active learning is promoted to faculty members over traditional lectures due to published findings of improved student learning. Active learning typically involves a break in the lecture to allow for problem solving, discussion, or other activities. One common type of active learning in large classes is classroom response systems (e.g. clickers). Based on classroom experience, the use of active learning with classroom response systems in large classes, particularly in the first year, can lead to a disruptive learning environment. In this preliminary study, a 1st year course and a 4th year course (n=120 and 135, respectively) were surveyed in Fall of 2015 to quantify student’s ratings of active learning with classroom response systems and disruption. The student’s impressions of active learning (e.g., interactive clicker problem solving) were assessed using a survey at the end of the course. Students were overwhelmingly positive about the advantages of active learning (>80% responded favorably) in the both courses. However, the students in the 1st year course had less positive feedback on active learning and higher ratings of disruption in the classroom than the students in the 4th year course (34% rated as disruptive in 1st year, 14% rated disruptive in the 4th year). The class rank, where higher values represented a greater number of years past secondary school, was positively correlated with rankings of a more disruptive environment suggesting that nontraditional students may find active learning more disruptive. This preliminary study suggests that using classroom response systems (clickers) in the 1st year curriculum with large class sizes may lead students to feel that the class was disruptive and that active learning was not as positive of an experience as active learning environments later in the curriculum.

Introduction

The President’s Council of Advisors on Science and Technology recommends increasing the number of STEM students by 34% annually using classroom approaches engaging students actively and replacing standard laboratory courses with discovery-based courses¹. The number of STEM students in higher education is expected to rise over the next decade. Currently, Bachelor’s degrees awarded in mechanical engineering have increased by 67% between 2004 to 2014 (14,182 in 2004 to 23,675 in 2014). In contrast, the number of full-time faculty only increased by 23% from 2001 to 2011 at US Universities². A longstanding and practical approach to accommodate larger number of students with decreasing faculty is to increase class sizes which typically favor traditional lecturing over active learning techniques.
Active learning improves examination performance and reduces failure rate in meta-analyses across science, technology, engineering and mathematics (STEM) courses when compared to traditional lecture styles\textsuperscript{2}. Active learning in large studies consists of many different types of interventions including group work in class, worksheets, problem based learning, and the use of classroom response systems\textsuperscript{3,4}. Active learning has been widely reported to improve noncognitive and cognitive outcomes but has not been widely accepted by faculty\textsuperscript{5}. Goffe and Kauper\textsuperscript{6} surveyed 275 instructors in higher education and found that 33\% believe that “students learn best from lecture”. The instructors in this survey cite the reasons for lecture preference as the ability to control the course material and the costliness of active learning techniques. Due to concerns over cost effectiveness, classroom response systems (or clickers) have been implemented into many lecture courses as an effective method to encourage active learning without sacrificing the control over lecture material.

Classroom response systems (e.g., clickers) have been found to improve student performance in large lecture classes\textsuperscript{7}. Caldwell\textsuperscript{8} stated that students in large classes are more hesitant to answer questions out of fear of public disapproval. Thus, the benefits to clicker systems include anonymity in large classes and the ability to assess student understanding in real time with graphical representations of the answers. The rapid feedback provided to students by clickers also positively influence student quiz performance in engineering courses\textsuperscript{9}. However, classroom response systems do not always lead to improvements in examination performance\textsuperscript{10}. A meta-analysis performed to resolve the conflicting findings on clickers found a small but significant effect on cognitive outcomes\textsuperscript{11}. A larger main effect was found on examining clickers effects on non-cognitive outcomes (e.g. self-efficacy, perception of quality, attendance, engagement and participation)\textsuperscript{11,12}. The benefits of using clickers in classes appears to diminish for class sizes greater than 50 students in terms of cognitive but particularly non-cognitive benefits\textsuperscript{11}. Hence, large class sizes may not see an advantage with cognitive outcomes while negative outcomes potentially including disruptive environment could be increased in these large class sizes.

The challenges to teaching large first year engineering classes include lower levels of retention, a lack of student preparedness for a rigorous curriculum, and large class sizes. In addition, psychological distress in college has been found to peaks during the freshman year\textsuperscript{13}. Another study found that students are entering college more “overwhelmed and damaged” with 28\% of students feeling frequently overwhelmed\textsuperscript{14}. The implementation of active learning in the classroom often requires students to take a more active role in the classroom and some students may be resistant to this type of learning\textsuperscript{15}. Disruptive behavior that may occur during active learning sessions often includes: disparaging the instructor, arguing with classmates, inattentiveness and side conversations, and active cell phone use during class. Research has shown that female students are less likely to engage in uncivil conduct\textsuperscript{16}. Mechanical engineering classes typically have a much larger percentage of male students than other majors which may lead to more disruptive classrooms during active learning. Classroom observations from the
Methods

Participants

In this study, active learning was examined in a 1st year course and a 4th year course to assess the occurrence of disruptive behavior. By testing two different years in the curriculum of one major, it was impossible to use the same course in the study. Two similar courses in the curriculum that require mathematical calculations and the use of computers were chosen for this study. The 1st year course was a numerical methods course that covers an introduction to Matlab programming, solving systems of linear equations, numerical differentiation, and numerical integration. The 4th year course was an engineering statistics course that covered computational applications of probability, uncertainty analysis, hypothesis testing, design of experiments, statistical process control, linear and nonlinear modeling, and multivariate statistics in Excel, Minitab, and Matlab. These courses are required courses for mechanical engineering students at a large, land-grant University in the western United States. Mechanical Engineering has a bachelor’s degree in mechanical engineering (ME) and a bachelor’s degree in biomedical engineering (BME) that includes coursework in mechanical engineering (9.6% BME, 1st year, and 8.3% BME in 4th year course). The only non-mechanical engineering majors in this study were 1 physics major, and 3 engineering science majors in the 1st year course.

Students in both courses were unaware of the study when they registered for the course. In the 1st year course 112 out of 117 participated in the study. In the fourth year course 117 out of 134 participated in the study. The 1st year course was 90% male and the 4th year course was 88% male. Chi-square analyses revealed no statistically significant differences in gender ($\chi^2[\text{df}=1]=0.383$, p=0.536).

Procedure

This study was conducted during the fall semester of 2015, during which the same instructor taught both the 1st year course and the 4th year course. The 1st year section was taught with three one-hour lectures. The 4th year course was taught with two one-hour sections and a one hour computer lab. An audience response system (iClickers) was used every day in both lectures to engage students, promote active learning, and to promote attendance. An average of
10 audience response questions was provided in each lecture for both courses. These were approximately 25% conceptual questions and 75% calculation based equations. Three midterm exams were administered for each course. The 1st year course included a final exam while the 4th year course included a final project. Student grades were based on homework assignments from the textbook (15% 1st year course, 10% 4th year course), class participation (5% 1st year course, 10% 4th year course), midterm exams (50% 1st year course, 45% 4th year course), final exam or project (30% 1st year course, 25% 4th year course) and laboratory assignments (10% 4th year course). The first two exams for both courses had an identical style that consisted of 20 multiple-choice questions. The third midterm for the 1st year course was a multiple-choice question and the third midterm for the 4th year course was a take home exam.

Classroom response questions (e.g., iclicker questions) were given during both courses. A typical example of an iclicker question for the 1st year course would be about solving a Matlab problem or setting up a numerical methods solution. For example, a picture of a function would be shown with maximums, minimums and roots and the student would be asked to “which labels on the image represent the roots of the function?”. A typical iclicker question for the 4th year course would be to present the results of a t-test and ask the students to identify the conclusions of the test as (1) reject the null hypothesis, (2) fail to reject the null hypothesis, or (3) accept the null hypothesis.

Assessments

Student Surveys

Students completed a survey at the end of the semester in each course that was designed by the instructor of the course. The survey began with a section to rate the knowledge of each concept prior to the course. The survey also included questions on the preferred format of the course and format of the homework. The students were asked questions about the atmosphere during active learning and to “Rate the level of disruption during active learning (1-5)”. The students were not given any information on the type of disruption to rank. The students were asked to rate their feelings towards positive learning (“Rate your positive feelings towards active learning (1-5)”) and “Rate your negative feelings towards active learning (1-5)”). The students were also asked questions on the best class size and number of proctors for active learning. In addition to the instructor survey, the students in this class were given a Colorado State University student course survey that asks general questions about the course and the instructor.

Statistical Tests

For direct statistical comparisons for questions based on the Likert scale, the nonparametric Mann Whitney test was used to determine differences in the responses between the two classes. For survey questions using frequencies between courses, a Chi-square contingency table analysis
was used to determine if the variables were independent or correlated with each other. A p-value < 0.05 was considered statistically significant for these tests. A spearman correlation coefficient (rho) was used to for correlation analysis of ordinal variables (significant p-value <0.05). The variables for the correlation analysis included gender (1-male, 2-female), class rank (1-first year student directly from secondary school, 2-second year student directly from secondary school, 3-first year of second bachelor degree, 4- second year of a second bachelor degree, 5-first year at CSU with an extended break between secondary school and university, 6-second year student with an extended break between secondary school and university), prior knowledge of Matlab (1 as no knowledge and 5 as complete knowledge), prior knowledge of numerical methods (1 as no knowledge and 5 as complete knowledge), final grade in the course (4.0-A, 3.7-A-, 3.3-B+, 3.0-B, 2.7-B-, 2.3-C+, 2.0-C, D-1.0, F-0.0). An ordinal logistic regression model was generated to predict the rating of disruption with the same variables as the correlation analysis listed above.

Results

Both classes were surveyed at the end of the semester and given extra credit for performing the survey. The overall response from students on the survey was 98% for the 1st year course and 87% for the 4th year course. The students were asked to rate their knowledge of the material in the courses prior to the semester (Table 1). The median rating of previous course knowledge was not statistically different between the two courses (median=2 for both courses) (Mann-Whitney test, p=0.1385). However, the distribution of the data was significantly different with more students in the fourth year course ranking their knowledge (2 out of 5) representing less knowledge, whereas the first year course has an even split between 1-3 out of 5 on the Likert scale (Table 1).

Table 1. The results of the survey questionnaire that included a Likert 5-point scale. The results are expressed as the observed frequency (percentage) for each scale value.

<table>
<thead>
<tr>
<th>Course</th>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st (n=111)</td>
<td>Rate knowledge of the subject matter prior to the class (1= no knowledge and 5=full knowledge)</td>
<td>31 (28%)</td>
<td>33 (30%)</td>
<td>33 (30%)</td>
<td>12 (11%)</td>
<td>2 (1%)</td>
<td>0.001 (X² test)</td>
</tr>
<tr>
<td>4th (n=110)</td>
<td>Rate knowledge of the subject matter prior to the class (1=no knowledge and 5=full knowledge)</td>
<td>23 (21%)</td>
<td>63 (57%)</td>
<td>19 (17%)</td>
<td>4 (4%)</td>
<td>1 (1%)</td>
<td></td>
</tr>
<tr>
<td>1st (n=112)</td>
<td>Rate the use of online homework (1 is love it and 5 hate it)</td>
<td>3 (3%)</td>
<td>61 (54%)</td>
<td>38 (34%)</td>
<td>7 (6%)</td>
<td>3 (3%)</td>
<td>&lt;0.0001 (X² test)</td>
</tr>
<tr>
<td>4th (n=117)</td>
<td>Rate the use of online homework (1 is love it and 5 hate it)</td>
<td>22 (19%)</td>
<td>71 (60%)</td>
<td>16 (14%)</td>
<td>7 (6%)</td>
<td>1 (1%)</td>
<td>&lt;0.0002 (X² test)</td>
</tr>
<tr>
<td>1st (n=111)</td>
<td>Rate positive feelings towards active learning (1 is not positive and 5 is very positive)</td>
<td>6 (5%)</td>
<td>12 (11%)</td>
<td>34 (31%)</td>
<td>45 (40%)</td>
<td>14 (13%)</td>
<td>&lt;0.0002 (X² test)</td>
</tr>
<tr>
<td>4th (n=117)</td>
<td>Rate positive feelings towards active learning</td>
<td>4 (3%)</td>
<td>7 (6%)</td>
<td>22 (19%)</td>
<td>36 (31%)</td>
<td>48 (41%)</td>
<td>&lt;0.0002 (X² test)</td>
</tr>
</tbody>
</table>
The active learning environment in the two classes included online homework assignments with instant feedback and class sessions with problem solving using iclickers. The first year course had a higher percentage of students ranking the online homework in a negative light (9% for 1st year and 7% for the 4th year). In addition, fewer students in the 1st year course gave a top rating (rating=1) for the homework (Table 1). The students were asked to rate their positive feelings towards active learning and their negative feelings toward active learning. Students in the 4th year had more positive feelings (rating =4 or 5) towards active learning than the 1st year students (53%, 1st year and 72%, 4th year). The percentage of students giving low rankings of positive feelings was 16% in the 1st year course and 9% of the 4th year course (Table 1). The rating of negative feelings towards active learning was not statistically different between the two courses were not statistically different due to an increase in 1st year students recording (60%) not negative (rating = 1 or 2). Despite the shift in 1st year assessment, the reliability between the rating of positive feelings and the rating of negative feelings correlation remained appropriate with a Chronbach’s alpha of -0.73.

The student’s impression of disruption during active learning session was of interest due to the drastic difference observed by the instructor in the two courses. The student rating was dependent on the year in the curriculum of the students (Table 1). Thirty-four (34%) of 1st year students ranked the course as disruptive (rating =4,5) whereas only 14% of the 4th year students found the course disruptive. Forty-six (46%) of students in the 4th year course gave low rating to disruption (rating = 1,2) versus the 36% of the first year students. Students felt there was an advantage to the active learning session (84% 1st year, 89% 4th year) but there was no statistically significant difference between the classes. In the 1st year course, fewer students responded that class size could be larger for non-active learning styles due to the disruptive nature of the technique (67% 1st year, 74% 4th year) (Figure 1). The students were asked to respond what class size they felt was best for active learning. Over eighty percent of students in both classes felt that a class size under 75 students was the best class size for active learning (80% 1st year, and 87% 4th year). Less than 10% of students in each course rated the actual enrollment (114 1st year, 134 4th year) in the course as the best class size for active learning (7% 1st year, 8% 4th year).
The 1st year students rated the course as more disruptive than the 4th year course based on the student surveys (Table 1). Several factors were identified to potentially model the disruptive classroom environment response in the 1st year course (gender, class rank, prior Matlab knowledge, prior numerical methods knowledge, and final grade in the course) (Table 2). There was a statistically significant correlation between class rank and the ranking of a disruptive classroom (Table 2). The correlation coefficient was positive which indicates that students with a higher numerical rank found the course more disruptive. The class rank system identified first time students (1&2) with a lower value than students returning for a seconds bachelor’s degree (3&4) or students coming to university with an extended break from secondary school (5&6). 73.15% of students were in the first two years of college directly after secondary school, 9.26% of students were in the first two years of a second bachelor’s degree, and 17.6% of students were first or second year students that taken an extended break between secondary school and college. Gender and prior knowledge of the course material were not statistically correlated with a rating of the disruptive classroom environment. An ordinal logistical regression model was generated based on the class rank of the students (p=0.019). The odds ratios were all below zero indicating for each value of the class rank. The highest ranked odds ratio was 0.64 for the second year students directly from secondary school. The Somer’s D coefficient for this model was 0.21 which indicates a higher number of concordant pairs, or a relationship between higher class rank and higher ranking of disruption.
Table 2. Correlation coefficients (Spearman rho) and p-values between ordinal variables and the student rating of disruption level in the 1st year classroom (1 is the lowest and 5 is the highest level of disruption).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spearman rho coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (binary)</td>
<td>0.078</td>
<td>0.427</td>
</tr>
<tr>
<td>Class Rank (1-6)</td>
<td>0.248</td>
<td>0.01</td>
</tr>
<tr>
<td>Prior Matlab Knowledge (1-5)</td>
<td>-0.035</td>
<td>0.718</td>
</tr>
<tr>
<td>Prior Numerical Methods Knowledge</td>
<td>-0.179</td>
<td>0.062</td>
</tr>
<tr>
<td>Grade in the Course (0.0-4.0)</td>
<td>0.043</td>
<td>0.660</td>
</tr>
</tbody>
</table>

The course survey data from the Colorado State University system collects data on the quality of classrooms and quality of instruction. The students in the 1st year course rated the class sessions and instructor significantly lower than the students in the 4th year course (Table 3). The lowest rankings were related to class session effectiveness and the clarity of the class activities. The instructor received higher ratings for knowledge of the material and enthusiasm compared to the classroom environment.

Table 3. Course survey results provided by Colorado State University (coursesurvey@csu). Statistically significant p-values (p<0.05) found in $\chi^2$ analysis

<table>
<thead>
<tr>
<th>Course Survey Question</th>
<th>1st Year Course (N=78)</th>
<th>4th Year Course (N=45)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>How well did class sessions increase your understanding of the subject?</td>
<td>2.78/5.00</td>
<td>3.35/5.00</td>
<td>0.015</td>
</tr>
<tr>
<td>How do you rate the clarity and completeness of instructions provided in the course for engaging in class activities and completing course work?</td>
<td>2.64/5.00</td>
<td>3.57/5.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>How effectively did the instructor facilitate student learning?</td>
<td>2.50/5.00</td>
<td>3.57/5.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>How did you rate the instructor’s enthusiasm for teaching the subject?</td>
<td>3.12/5.00</td>
<td>4.47/5.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>How did you rate the instructor’s knowledge of the subject?</td>
<td>3.37/5.00</td>
<td>4.47/5.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>How do you rate the instructor’s effectiveness at managing class sessions?</td>
<td>2.31/5.00</td>
<td>3.80/5.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>How well did the instructor create an atmosphere that was respectful of student opinions, ideas and differences?</td>
<td>3.13/5.00</td>
<td>4.20/5.00</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Discussion
In summary, the student’s positive ranking of active learning with classroom response systems in the 1st year classroom was lower than the 4th year ranking of active learning with classroom response systems (Table 1). However, the classes responded very similarly and positively (> 80%) as to whether there was an advantage to active learning over traditional lecture styles. Active learning techniques (particularly clicker-based technology) are favored by students over traditional lecture styles\(^9,17\). Many researchers have posited that the increases in learning and enjoyment come from the break in the lecture as typical attention spans are documented at approximately 15 minutes\(^9\). The students in this study were asked to describe the advantages of active learning when they responded positively to the question “is there an advantage to active learning sessions”. The answers to this question included: 35% responded that active learning kept them from tuning out and 30% felt that they were able to recognize problems better due to the active learning questions. These responses follow the research that the breaks in the learning may help students retain more information from the lecture material.

The administration of this survey followed observations of very different class behaviors from two different cohorts at different levels in the curriculum with a similar teaching method. Although clicker-based response systems are often promoted to engage active learning in large classes, the students do not necessarily believe that large class sizes work well with clicker-response systems due to potential disruption between interactions (Figure 1). Hunsu et al.\(^11\) found that large class sizes diminished any positive outcomes from the use of clickers in the classroom. In addition, meta-analyses suggest that cognitive outcomes from science and engineering courses with iclickers are non-existent (g=-0.001)\(^11\). Hunsu’s findings present an opening for future work to compare the two classes in reference to disruption with traditional lecture styles versus active learning. The potential questions include “do students have better cognitive outcomes traditional and active learning classes”.

Nontraditional students or students over 25 years of age are an increasing population in college classrooms\(^18\). The percentage of second bachelor’s degree students in the 1st year classroom was 9.26% versus 0.022% in the 4th year classroom. The high ranking of disruption was correlated with the class rank of the students. Thus, nontraditional students often ranked the course as more disruptive than lower ranked students. Nontraditional students have a higher risk of dropping out\(^19\), which may explain the reduced numbers in the fourth year course. Nontraditional students have been classified into several theoretical frameworks\(^20,21\) that promote that nontraditional students prefer self-direction in learning and more control of the learning environment. Active learning via iclickers provides more control over the learning environment but can also be frustrating to the nontraditional students. Iclickers do not allow for a self-directed learning environment and decrease the amount of class time that is spent on concrete material. More research is needed to understand the perception of classroom response systems with nontraditional students.
Another interesting analysis may be to assess the psychological effects that more decentralized active learning environments have on the faculty and their perceptions of disruptive classrooms. Goffe and Kauper found that instructors are resistant to using active learning due to the potential of losing classroom control. A proctor was sent into the 1st year course in this survey to provide input on the instructor’s effectiveness and classroom behavior. The proctor’s findings were overwhelmingly positive and he felt that the disruption was an important part of the learning process. The students were hard to get back on task but they were talking about engineering concepts with more interest and excitement than the proctor’s experience in the fourth year courses and graduate courses. Although, the proctor did recommend using a bell or noise system to bring the focus back to the next topic. Classroom control methods could help promote the active learning sessions and reducing any disruptive behaviors. Faculty and student often do not agree on the most effective classroom management strategies; student often preferring more aggressive methods (e.g., dismissing the class, yelling at the student). Conference attendees on the topic of disruption in the classroom promoted two different strategies: (1) a punitive approach with consequences, (2) an educational approach by asking the students for help. The proctor in the 1st year course in this study had an interesting point that a “disruptive” or noisy classroom can be a classroom where learning is occurring. However, the student’s did rank the class as disruptive and the instructor received significantly lower evaluations even though the class may have improved learning (Table 3). These findings highlight the fact that faculty may have a valid fear of losing control of courses when it comes to faculty evaluations. As long as student rankings of the instructor remain the only indicator of teaching, it may be difficulty for faculty to have more disruptive learning environments.

The study was limited to a comparison of active learning and disruption by year rather than active learning to traditional teaching styles. First (1st) year courses were found to have the highest potential for disruption during active learning and a less positive view on active learning sessions. Future comparisons between traditional lecture style and active learning should be performed during the 1st year to isolate the factors and interventions that may improve disruption in the classroom. A study is planned for next year using more traditional learning techniques to allow comparisons of student performance on the material and the student’s ratings of disruption. It is possible that the disruptive class environment could outweigh the positive gains in active learning with respect to retention of diverse students. Overall, this study provides an excellent starting point on one potential downside to active learning using clickers in large classes. Institutions may need to reconsider large class sizes with clickers to take advantage of improvements in exam performance and benefits in terms of cognitive and non-cognitive outcomes.

References


