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Active learning classroom design and student engagement: An exploratory study

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Three student engagement measures were collected for a class taught by an experienced instructor in two active learning classrooms with dissimilar seating arrangements. Student perception of engagement was similar between the learning spaces. However, instructor perception and researcher observation indicated greater engagement in the classroom with mobile tables compared to the classroom with mobile desks. STROBE classroom observations indicated qualitatively different student-to-student (8% greater), student-to-instructor (3% greater), and student self- (6.5% less) engagement in the mobile table classroom over the mobile desks classroom. Instructor and student perceptions may interact to affect student engagement with various designs of active learning classrooms.

Active learning is generally described as any pedagogical strategy that engages students in the learning process (Prince, 2004). In active learning, students participate in meaningful individual or group activities that require thinking about, and reflecting upon, what they are doing (Bonwell & Eison, 1991). The student-centered nature of active learning contrasts with the instructor-centered atmosphere of lecture-based pedagogies. Lecture-based instructional approaches view the learner as a passive recipient of the instructor's expertise, whereas active learning pedagogies perceive the learner as an engaged participant in the learning process (Sabagh & Saroyan, 2014).

Research examining the utilization of active learning pedagogies compared to lecture-based instruction has shown positive and substantial outcomes in university students' academic performance and learning (Beichner et al., 2007; Dori et al., 2003; Freeman et al., 2014; Prince, 2004; Knudson, 2019; Knudson & Wallace, 2019), engagement (Bolden et al., 2019; Wiltbank et al., 2019), satisfaction (Hyun et al., 2017), and motivation to learn (Adedokum et al., 2017). Additionally, recent reports indicated active learning approaches may be equally effective with both low-tech and high-tech (enhanced with networked computers and displays) implementations (Knudson & Wallace, 2019; Soneral & Wyse, 2017). Thus, there is a growing body of evidence in support of student-centered, active learning instruction in higher education settings.

Active Learning Classrooms

While student-centered instruction can occur in any style classrooms, *active learning classrooms* (ALCs) are purposefully designed to promote student engagement in the learning process (Adedokum et al., 2107; Baepler et al., 2016; Freeman et al., 2014; Wiltbank et al., 2019). The origin of ALCs is often linked to the creation of "physics studios" at Rensselaer Polytechnic Institute in the 1990s (Wilson & Jennings, 2000; Wilson, 1994). Physics studios were designed to enable small groups of students to participate in lab-type activities in classes with moderate enrollments (e.g., 50-64). Prior to physics studios, the introductory physics classes at Rensselaer Polytechnic Institute were taught in large lecture halls and labs were conducted separately. Costs associated with conducting lectures and labs independently combined with the expense of tutorial sessions stimulated the course structure and learning space redesign.

ALCs gained additional momentum when Beichner et al. (1999) designed the Student-Centered Active Learning Environment with Upside-down Pedagogy (SCALE-UP) project for high enrollment physics classes. Classrooms included large round tables designed to seat nine students who worked collaboratively in smaller groups of three. SCALE-UP classrooms were equipped with technology (e.g., computers, projection screens, and whiteboards), and the placement of the large round tables eradicated a definite location for the front of the classroom. Faculty teaching in

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SCALE-UP classrooms utilized student-centered pedagogies that promoted activity-based instruction and collaboration with peers.

The Technology Enabled Active Learning (TEAL) initiative occurring at the Massachusetts Institute of Technology during the same time also incorporated active-learning instruction in redesigning classrooms for physics courses. In addition, TEAL included electronic technology that afforded students the opportunity to access two- and three-dimensional visualizations of physics principles (Dori et al., 2003). Studies examining the impact of the SCALE-UP and TEAL projects have demonstrated significant improvement in students' engagement, attitude, problem-solving skills, and learning over traditional lecture instruction (Beichner et al., 2007; Dori et al., 2003).

The SCALE-UP and TEAL projects heightened academia's interest in, and implementation of, active learning instruction as well as the creation of ALCs. Learning spaces designed to promote active learning methodologies generally include movable chairs and tables, portable white boards, multiple viewing screens, varied levels of computer/electronic technology, and are arranged with no definitive front of the classroom (Baepler et al., 2016; Rands & Gansemer-Topf, 2017). However, many distinct ALC designs exist with notable variety in the seating arrangement. SCALE-UP and TEAL classrooms typically included round tables that seated nine students per table enabling students to collaborate in teams of three. However, smaller SCALE-UP classrooms utilize D-shaped tables arranged to accommodate classroom space (Beichner, 2014). Other types of classroom seating configurations designed to promote student engagement include mobile square tables with movable chairs (Knudson & Meaney, 2018), moveable rectangular tables (Soneral & Wyse, 2017), trapezoid tables with chairs on coasters and individual mobile chairs (Harvey & Kenyon, 2013). Prior literature comparing traditional classrooms to ALCs are plentiful; however, more investigations are needed to explore differences between distinct ALC designs to inform design decisions and ensure appropriate allocation of limited university funds.

Experiences and Perceptions of Active Learning Classrooms

Evidence suggests student and faculty perceptions of formal learning spaces differ. Odum and colleagues (2020) interviewed faculty and students at the end of an inaugural semester teaching and learning in a newly designed ALC. While both groups preferred the ALC to the previous traditional learning space, faculty identified the modular tables as a barrier to implementing active learning techniques while students identified them as a key to their connectedness with classmates. Granito and Santana (2016) also reported differences between student and faculty perceptions regarding effectiveness of technology and the importance of the physical classroom on student learning. Rezaei (2020) further highlighted student-instructor perception differences in a recent cross-sectional survey completed by 771 students and 47 faculty reporting stark differences in perceived utility of the teacher's location in the room and writable surface tables. Despite existing dissimilarity of instructor and student perspectives about learning spaces, a disparate number of past studies have presented only student perceptions of classroom redesign (King et al., 2015). Studies inclusive of all stakeholder perceptions are needed to offer a robust representation of user experiences and perceptions to inform ALC design and utilization.

Student Engagement

A primary goal of active learning pedagogies is to promote student engagement during the learning process. Metzger and Langley's (2020) study highlighted particular patterns of student engagement across 23 classes, including three forms of engagement (listening/processing, discussing, and problem solving) that explained 74% of all observed learning behaviors. Talbert and Mor-Avi's (2019) review of 37 ALC studies confirmed the positive impact of student-engaged instruction on learning outcomes. Moreover, the review highlighted that the aspects of mobility, visual layout of the classroom, and access to tools for learning (e.g., personal and group whiteboards, writeable tabletops, and technology) in ALCs nurtured connectedness among the students and between the student and instructor. Indeed, these aspects are all critical components of ALCs intended to nurture collaborative learning, interactions between students, and the position of the instructor as a facilitator of learning (Park & Choi, 2014).

Prior studies have provided evidence that ALC designs are more conducive than traditional classrooms to fostering students' engagement (Zimmermann et al., 2018) and collaborative learning activities (Clinton & Wilson, 2019). One study comparing a traditional classroom to a technologically-enhanced ALC reported evidence of casual relationships between classroom type and observed instructor and student engagement behavior (Brooks, 2012). What is lacking in the literature are comparisons of student engagement within dissimilarly designed ALCs controlling for instructor and content.

Study Purpose

The purpose of this study was to explore whether student engagement differed among two sections of a course taught by one instructor in two distinctly designed ALCs. To

achieve data triangulation, perceptions of student engagement were collected from students, the instructor, and the research team. Three research questions guided this inquiry:

1. Does self-reported student engagement differ by classroom?
2. Does instructor-observed student engagement differ by classroom?
3. Does researcher-observed student engagement differ by classroom?

Method

Context and Sample

This study occurred at a large public university with a 'doctoral university higher research activity' Carnegie classification and Hispanic Serving Institution designation. During the semester data collection occurred, the university enrolled approximately 38,000 students (approximately 59% women, 56% racial or ethnic minority). The course included in the study was required for majors within the exercise and sports science academic program, housed within an academic department serving nearly 3,000 students (approximately 56% women, 65% racial or ethnic minority).

The department recently transformed two classrooms from traditional to active learning spaces. Classroom renovations included replacing stationary desks with mobile tables and chairs (classroom MT) or mobile desks (classroom MD). Both classroom renovations also included the installation of multiple projection units and mobile whiteboards to support active learning instruction. Additionally, the department delivered a six-hour professional development program to support faculty transition to the active learning space, a complete description of which is published elsewhere (Knudson & Meaney, 2018).

This study utilized a convenience sample (n=62) of two sections of a sophomore-level exercise and sports science class taught by one instructor. One section attended class in classroom MD and the other in classroom MT. All students in both classroom MD (n=25) and MT (n=37) were invited to participate. Fifty students consented to participate for a response rate of approximately 81%. Course delivery remained consistent across the sections with identical learning objectives, curriculum, schedule, and assessments. Figure 1 displays classroom photos and further details follow. All study procedures were approved by Texas State University institutional review board.

Data Collection

To achieve triangulation, data collection included three distinct measures of student engagement: (a) student self-reports recorded with a brief survey, (b) instructor perceptions shared during an in-depth interview, and (c) classroom observations completed by the research team. Before the semester began, the instructor provided written consent to participate in the study allowing researchers to: (a) visit the class at the beginning of the semester to invite students to participate and collect student demographic data, (b) observe three lessons in each classroom and collect student engagement data with a survey, and (c) interview the instructor.

Student Survey

At the beginning of the semester, students provided written consent to participate in the study and completed a demographic questionnaire. At the end of each observed class period, students completed a brief self-engagement scale to report their perceptions of engagement during that class meeting. Students received no compensation for participation. To encourage honest responses, the research team chose to collect student engagement reports anonymously.

To measure student self-reported engagement, the team selected a 9-item scale published elsewhere (O'Malley et al., 2003) with reported good internal consistency (Cronbach's alpha of .84). Scale instructions requested participants select their level of agreement on a 5-point Likert scale (strongly disagree to strongly agree) with statements about their learning behaviors in class. Example items include statements about contributions to class activities that day (e.g., "I contributed meaningfully to class discussions today") and their overall self-assessment of engagement (e.g., "I was mostly an active learner in class today"). The full list of scale items can be seen in Table 2. The research team made no edits to scale items; however, they added examples of passive and active learning behaviors to provide context for students who may have been unfamiliar with these concepts.

Instructor Interview

At the end of the semester, the lead author conducted an in-depth interview with the instructor. The interview protocol questions developed for this study asked the instructor to share her perspective of the engagement of students in each classroom throughout the semester and whether the physical set-up of the classroom impacted her instructional methodologies. Upon the instructor's request, the lead author shared the interview protocol in advance so she could prepare thoughtful examples of how the

Figure 1. **Active Learning Classroom Spaces.**

Note. Top panel: Active learning classroom with mobile desks (classroom MD). Bottom panel: Active learning classroom with mobile tables and chairs (classroom MT). Both classrooms included two projectors with screens on two different classroom walls and mobile whiteboards to support active learning instruction.

classroom impacted her teaching approach and perceptions of student engagement. The interview occurred in the lead author's office and lasted 36 minutes. The instructor received no compensation and provided written consent to be audio recorded and contacted at a later date for a member check (Lincoln & Guba, 1985).

The instructor had taught full time at the university for 10 years with 5 years of experience implementing active learning pedagogy and 9 years teaching the class of focus. She completed the department training one year before this study began and had taught in the department's inaugural ALC (classroom MT) for two semesters. Department renovations converted classroom MD into an active learning space the summer before this study, so data collection occurred during the inaugural semester after renovations. When asked to describe her teaching approach and philosophy, the instructor replied:

> *Active learning is a huge part of my teaching philosophy. I would meet students twice a week, and at least one lesson per week involved cooperative learning, so I'm using one of these [active learning] methodologies. I would incorporate every single day a brain break, at least [one], and then some sort of ice breaker or cooperative learning method. […] My active learning philosophy is definitely strong, meaning that I find it very useful. I have many students say that they love the class, the classroom management, the classroom style, or my teaching style for hands on and partnering that with direct instruction. So, I plan to keep using that. Even with 65 [students enrolled] in my class, I try to use active learning. So, definitely I think that is important to try and meet all the teaching, all of learning styles of adult students, which is, you know, anywhere from direct instruction all the way to corporative learning.*

The instructor shared that her teaching pedagogy included blending direct instruction and active learning methods:

> *I don't do direct instruction every class. There's some days that I do a jigsaw, and that will be the entire class instruction. It definitely depends on what the main point of the day is. For example, one day we're talking about socialization and development, and how it impacts the developmental structure. That's a really good day to jigsaw that out, because it's not a super conceptual, you know? It's more big concepts, so it's an easy jigsaw. That's a day that I don't do any direct instruction. It's an easy blend [because] the day before that is more direct instruction, so it's a good break from the more tedious kind of learning direct terms and things like that. I really try to, for the students that like PowerPoint or more dialog or discussion in*

class and that kind of thing, where they are more tied to partner work and things, where you know, I feel like that some students really do well with that, and they like writing notes, and talking with the partner, so even in direct instruction I have them doing partner work, and answering questions as a group, and using like Padlet or some sort of technology. So, even if it's direct instruction they're not just sitting there looking at PowerPoint screen; I do try to blend, even if I'm using PowerPoint.

Classroom Observations

The research team used the STROBE observational instrument (O'Malley et al., 2003) to record student engagement on 5-minute observation cycles. Prior studies have demonstrated adequate inter-rater reliability as demonstrated by kappa coefficients of .79 (O'Malley et al., 2003) and .87 (Alimoglu et al., 2014). The STROBE scoring sheet included macrolevel observations (structure of class, the main teaching activity at the time of data collection, and a global judgment of the proportion of students who appear to be on task) and microlevel observations (instructor and randomly selected student behavior).

Three observers completed a 3-hour training session and practiced observations in four class sessions (two in each classroom of focus). Kappa coefficients indicated good inter-rater reliability for practice observations ($\kappa = .79$, $p < .001$). Based on practice sessions, the researchers altered the instrument in two minor ways. First, the team adjusted the format of the instrument to facilitate ease of recording data by adding a space for observers to note a quick student description (e.g., "red sweatshirt," "plaid hat," etc.) at the beginning of the 20-minute cycle to help track students as they moved into sub-groups. Second, the researchers expanded "tally of questions spoken by student" to also include questions answered by students.

Prior to the semester, the instructor shared a class schedule noting days of active learning techniques in the classroom, which occurred primarily in weeks 1-8. Weeks 9-15 of the term included a service-learning component and the class met off campus to apply course concepts in a practical setting. Practice observations in classrooms MD and MT occurred in weeks 2 and 3 (with classes taught by different instructors) with STROBE observation sheet edits and re-training in week 4. Thus, the research team collected data for this study in weeks 5, 6, and 7 with observations of the same three lessons in each learning space.

Two study authors and one graduate student completed observations, with two observers attending three 80-minute class sessions in each classroom for a total of six observed classes. Before the class began, the two observers visualized the classroom into four quadrants and each observer selected one student per quadrant as a starting point. Four, 5-minute observations then occurred to complete one observation "cycle" with an observation focused on the students seated immediately in front of, behind, and to either side of the randomly selected student. When students physically moved during the cycle (e.g., for group work), the observers tracked their movement and continued observations. Observers attempted to select a different student in each quadrant for each cycle but repeats did occur due to small class enrollment. Three, 20-minute observation cycles occurred each class period, for a total of 360 minutes of observation.

Data Analysis

Quantitative analyses occurred with SPSS version 25 and qualitative analysis occurred with NVivo version 12. Given the exploratory nature of the study, an *a priori* type I critical *p*-value of < .05 was used for statistical tests. Missing data were excluded with pairwise deletion. A significant main effect for time was followed-up with Tukey *post hoc* tests.

Student Survey

Student demographic characteristics were manually entered in SPSS and analyzed descriptively (sex, age, race/ethnicity, class, major, native language). Student self-reported engagement data were manually entered into SPSS, items 2 and 6 were reverse coded, and an average of the nine items was calculated (see O'Malley et al., 2003). Scores ranged from 1 to 5 with higher scores indicating greater perceived engagement. Independent samples *t*-tests assessed differences in overall scores by classroom. Repeated measures ANOVAs could not be performed because data were collected anonymously (student identities were not recorded).

Instructor Interview

A graduate research assistant drafted an interview transcript with clean speech (Merriam & Tisdell, 2015). The lead author edited the transcript by listening to the recording multiple times, making necessary edits. The lead author conducted a thematic analysis by listening to the recording and reading the transcript and field notes. The simultaneous analysis of written transcripts, audio-recordings, and field notes has been found to increase effectiveness of qualitative data analysis (Tessier, 2012). The second author provided feedback on the results. During a member check, the participant confirmed findings accurately represented her perceptions and approved all descriptions and quotes for publication.

Classroom Observations

Classroom observation data from the six observed sessions were tabulated by student learning behavior and entered into SPSS. STROBE engagement sub-scales were organized by type of observed student engagement behavior: Student-to-student; student-to-instructor; and self-engagement. Independent samples *t*-tests assessed differences in overall mean observed engagement scores by classroom.

Results

Sample Characteristics

Participating undergraduate students (*n*=50) were predominately male in both classroom MD (72.7%) and classroom MT (77.8%) with mean ages of 20.4 years and 21.6 years, respectively. Students in both classrooms most frequently reported their race/ethnicity as white only (36.4% and 44.4%, respectively), followed by Hispanic (31.8% and 40.7%, respectively) and Black (22.7% and 7.4%, respectively). Students in classroom MD most commonly reported being juniors (50.0%) while those in classroom MT most commonly reported being sophomores (62.9%). Table 1 presents further sample characteristics.

Student Survey

Cronbach's alpha (.813) indicated good reliability for student survey data. No statistically significant association was found between student self-reported engagement and classroom (*t*=(-.1.71), *p*=.090). Therefore, student perception of overall engagement did not differ (Table 2) by classroom (research question 1). Upon observing mean engagement scores were qualitatively larger over time in both classroom MD (3.9, 4.0, and 4.3, respectively) and classroom MT (4.2, 4.2, and 4.3, respectively), we conducted a one-way ANOVA to assess differences in overall mean self-reported student engagement scores by lesson (lesson 1, lesson 2, lesson 3). The ANOVA found, however, that this trend did not reach our standard for statistical significance (F(2,138) = 3.02, p=.052).

Instructor Interview

Thematic analysis revealed three overarching themes related to the instructor's perceptions of the ALCs and student engagement. The first theme, *classroom design impacted student learning expectations*, revealed the instructor's perception of student learning expectations based on their initial impressions of the learning space. For example, the instructor shared classroom MD students expressed expectations of a traditional, lecture-style class based on the physical layout while classroom MT students expressed expectations of team-based learning on the first day of the term. The second theme, *student engagement differed by classroom design*, revealed how the instructor perceived classroom-specific differences in student-to-student engagement (sub-theme 1) as well as engagement with her and instructional activities (sub-theme 2). The third theme, *barriers to implementing active learning methods*, disclosed obstacles to active learning techniques differed by classroom. Themes, sub-themes, and representative quotes are presented in Table 3.

The instructor perceived greater student engagement in classroom MT compared to classroom MD and attributed the engagement differences to the learning space design. For example, the instructor noted classroom MT students more effectively engaged from the first day of the semester compared to classroom MD peers. The instructor also stated a preference for classroom MT to deliver active learning pedagogies: "If I could teach in there every day, I would." However, she revealed a preference for either ALC, in general, over traditional, lecture-style classrooms: "I think we're really lucky as a department to be able to have these active learning classrooms […] we're lucky to have either one; but obviously if we get the choice, having the table-type setting would be better." Therefore, student engagement did differ by classroom from the instructor's perspective (research question 2).

Classroom Observations

Table 4 presents frequencies and proportions of observed student engagement recorded for all subscales of the STROBE observation form. No statistically significant associations were found by classroom for any of the student engagement behaviors: Student-to-student engagement behavior (*t*=0.11, *p*=.922); student-to-instructor engagement behavior (*t*=1.63, *p*=.179), or student self-engagement behavior (*t*=0.56, *p*=.590). Therefore, observed student engagement did not differ by classroom design (research question 3).

Mean observed engagement scores were also qualitatively noted to be larger as the course progressed (see Table 4), so ANOVAs were conducted to assess differences in mean scores over time for the three types of student engagement. No statistically significant associations were found between observations of student-to-student engagement ($F(2,3) = 1.68$, $p=.324$) or student-to-instructor engagement ($F(2,3) = .01$, $p=.993$) and lesson. A statistically significant association was found between STROBE observation of student self-engagement ($F(2,3) = 12.91$, $p=.034$) by lesson, with mean observation scores increasing from lesson 1 (29.0) to lesson 2 (50.5) to lesson 3 (61.5).

Discussion

This study is unique in its exploration of student engagement in two distinctly designed ALCs from the perspective of students, the instructor, and the research team. Inclusion of multiple stakeholder perspectives achieved data triangulation that strengthens the findings of this exploratory study, as well as the current body of literature that has presented a disparate number of studies including only student perceptions of classroom redesign (King et al., 2015). A more robust exploration of student engagement within distinct ALCs is needed to inform classroom design decisions and ensure appropriate allocation of limited university funding.

Results were inconclusive on the effect of the ALC design on student engagement. The instructor qualitatively perceived differences in student engagement by classroom with the MT fostering more interaction than the MD design. Conversely, classroom differences in student self-reports and classroom observations of engagement failed to achieve statistical significance. This difference in perceptions of active learning spaces between students and the instructor was consistent with recent investigations exploring student and faculty perceptions of the impact of ALCs (Granito & Santana, 2016; Odum et al., 2020; Rezaei, 2020).

The instructor unwaveringly viewed student engagement in classroom MT to be better than student engagement in classroom MD from the initial class meeting to the end of the semester. The main design difference in the two learning spaces was seating structures (i.e., desks versus tables); otherwise, the classrooms contained comparable technologies and tools to facilitate active learning modalities. Whether the instructor's perspective was representative of other faculty was beyond the scope of the current study and future investigations with more faculty members may be beneficial to explore a broader range of instructor experiences. It is conceivable that developmental activities held in the learning spaces that allow faculty to experience the space as a learner, identify constraints of the classroom tools, and plan their teaching approach for the space (Birdwell & Uttamchandani, 2019) may be beneficial.

Observed classroom MT engagement scores were qualitatively larger for STROBE measurements of student-to-student and student-to-instructor engagement (8% and 3%, respectively), while student self-reports of engagement were qualitatively smaller (6.5%) compared to classroom MD. This trend of engagement scores was consistent with expectations of the types of student engagement behaviors during team-based learning activities. Similarly, mean scores for student perceptions of engagement were qualitatively higher (1-6%) for each lesson in classroom MT compared to classroom MD (Table 2). Reliability analyses indicated good reliability for both student survey and STROBE observation measures, but there is limited previous research or understanding of what increase in these scores is pedagogically meaningful (Hunt et al., 2003; Kelly et al., 2005; O'Malley et al., 2003). While these measures of student engagement showed no clear differences by learning space in this study, other than qualitatively confirming the instructor's perception of greater engagement in classroom MT compared to classroom MD, future studies with larger samples are recommended to explore whether student engagement differs in dissimilar ALCs.

Mean scores from STROBE observations and from student surveys qualitatively increased in both classrooms during the observation period. Researcher-recorded observations of engagement behaviors were dramatically (96 to 126%) larger for lesson 3 compared to lesson 1 (Table 4). Increases in student perception of engagement over this time was smaller (1-6%) than the observational measures, but followed a similar trend (Table 2). Together, this evidence supports the conclusion that the active learning instruction with this instructor and these ALCs increased student engagement as the semester progressed, with engagement levels consistent with prior research on active learning strategies (Alimoglu et al., 2014; Kelly et al., 2005).

Data from STROBE observations revealed student-to-student was the most frequently noted engagement behavior in both classrooms during the observed class sessions, followed by student-to-instructor and self-engagement (Table 4). Consistent with the instructor's perception that classroom MD students kept to themselves unless prompted to work together, the STROBE observations for self-engagement behavior was qualitatively larger (6.5%) in classroom MD compared to classroom MT. The current study of classroom observations found proportionately more student-to-instructor engagement than reported in previous studies with similar classroom settings (Hunt et al., 2003; Kelly et al., 2005).

While results indicated these two classroom designs were not associated with observed and perceived differences in student engagement, it is possible the small sample size had inadequate statistical power to detect small effects between these two designs. Also, a ceiling effect of high student self-reported engagement could limit the ability to detect medium or large change in the student perceptions over time or between classrooms. Because statistical significance calculations are influenced by sample size, we recommend additional studies with larger samples to examine whether a direct association exists between ALC design and student engagement, irrespective of instructor and curriculum.

Limitations

Several limitations of this study should be considered. First, this study was limited to a small, convenience sample

of two sections of a course taught by one instructor at one institution, limiting generalizability of results. This weakness was mediated by good control of room and instructor variables. The three-prong approach to measuring student engagement from the perspective of the instructor, the research team, and the students also provided rich data that achieved data source triangulation, which strengthened findings (Carter et al., 2014).

Second, student self-reported engagement data relied upon the truthfulness of participant responses. Nevertheless, analysis of reverse score scale items revealed no signs of deception. Anecdotally, while talking to students after observed class sessions, most students reported actively participating during most of the class period, which corroborates the self-report survey data and the observation data.

Third, this study explored instructor perceptions of student engagement qualitatively with an in-depth interview, yielding findings inherently limited by time and context (Lincoln & Guba, 1985). However, best practices for data collection and analysis strengthened the robustness of data. Specifically, the following methodological decisions and techniques strengthened findings: (a) multiple members of the research team conducted data analysis, (b) analysis included audio-recordings and field notes in addition to the written transcript, and (c) a member check indicated participant agreement with accurateness of findings. It is also possible that preference for the MT classroom could be unconsciously communicated and influence student perceptions of engagement. We do not believe this was an issue given the instructor expressed a positive view of both classrooms in her preference for implementing active learning pedagogy.

Fourth, the STROBE observation process was limited to recording behaviors perceptible to observers. For example, students who appear to be looking at the textbook might be recorded as "reading" and "self/notes" when they could actually have been lost in thought and not reading. Thus, the STROBE data relied heavily on the assumption that students who appeared to be engaged in the recorded behavior actually were, and the STROBE may misclassify some student behaviors. However, given the high level of agreement evident from inter-reliability tests and a lack of significant coding differences among individual observers, this seems highly unlikely. Additionally, qualitative increases in engagement noted on the STROBE observations were corroborated by results of quantitative student survey data and qualitative instructor perceptions. Furthermore, the STROBE values in this study are similar regarding proportion of self-engaged behaviors, but indicate less student-to-student engagement and more student-to-instructor engagement than a prior study observing team learning (Kelly et al., 2005).

Conclusion

This study confirmed increases in student engagement over time with active learning in two redesigned classrooms with instruction by an experienced faculty member, but results were inconclusive on whether student engagement in the two ALCs were different. Trends for this instructor, student, and observation data warrant replication or extension studies with larger samples and across other disciplines. Specifically, future studies should explore whether dissimilar ALC design independently impacts the apparent interaction of instructor and student perspectives affecting student engagement.

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Appendix

Table 1. ***Sample Characteristics (n=50)***

	Classroom MD		Classroom MT	
	n	**%**	**n**	**%**
Sex				
Male	16	72.7	21	77.8
Female	5	22.7	6	22.2
Age				
Mean age (years)	20.4		21.6	
Race/ethnicity				
Asian	0	0.0	1	3.7
Black or African American	5	22.7	2	7.4
Hispanic or Latino	7	31.8	11	40.7
Native Hawaiian or other Pacific Islander	0	0.0	1	3.7
White	8	36.4	12	44.4
Student Classification				
Freshman	2	9.1	1	3.7
Sophomore	9	40.9	17	62.9
Junior	11	50.0	7	25.9
Senior	0	0.0	2	7.4
English native language				
Yes	19	86.3	25	92.6
No	3	13.6	2	7.4

Note. MD = active learning classroom with mobile desks group; MT = active learning classroom with mobile tables group; Differences in *n* due to missing data.

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Table 2. ***Means and Standard Deviations of Student Perceptions of Engagement***

Item	Classroom MD		Classroom MT	
	M	**SD**	**M**	**SD**
I contributed meaningfully to class discussions today	4.2	.77	4.3	.87
I was not paying attention most of the time in class*	4.3	.75	4.5	.84
I contributed my fair share to class discussions	4.0	.88	4.2	.86
I participated in class discussions today	4.1	.92	4.3	.81
I talked in class with other students about class material	4.6	.53	4.7	.48
I was mostly a passive learner in class today*	2.5	1.08	2.6	1.35
I paid attention most of the time in class	4.6	.56	4.6	.54
I was mostly an active learner in class today	4.1	.95	4.5	.82
Most students were actively involved in class today	4.4	.72	4.5	.68
Total	**4.1**	**.52**	**4.2**	**.52**

Note. Self-perception of engagement scores from 1 to 5 from the instrument by O'Malley et al. (2003). MD = active learning classroom with mobile desks group; MT = active learning classroom with mobile tables group; asterisks denote survey items that were reverse coded.

Table 3. ***Instructor Perceptions of Student Engagement***

Theme	Representative quotes
Classroom design impacted student learning expectations	• I honestly think that the desk puts them in a traditional setting [in classroom MD]. Once they go in and they see the desks, they're thinking traditional; this is going to be a traditional class. "I'm in a desk, teach me traditionally." And then you come in and you're trying to put them [in learning groups]. I'm just guessing. And they get into a mindset, you know? "I'm at a desk and I want to be in a row and I want you to give me a PowerPoint." And then you come in and you're like, "Oh no, no, no, no. See this diagram? We're gonna be in groups". And they're kind of like, "Ugh, no! What? This is a desk!" But with the tables [in classroom MT], they walk in and they're already set. This is not traditional, this is different. • […] with the tables [in classroom MT], you still have a clue about your personal space because the person in front of you is 10 feet away. So, you're like, okay, that's cool. But in the desk [in classroom MD], they're smaller and so you're kind of still, you know, it's kind of small in relation, but the desks seem big and spread out. So, you still kind of have […] your own thing, you know? And then those desks read traditional, you know? I think they come in with a mindset already. The tables are not traditional. Tell me what you're going to do. I want to know what's going to happen. And they are already thinking something's not traditional in here. But the desks are traditional [so the student reaction is], you're gonna change things up on me? Nuh uh! So, and I really think that was one of the things with my class is that every day they were still hoping for traditional, you know, and I wasn't giving it to them. And, so, they were a little resistant, […] they kinda threw up some "I don't want to do that, you know, can we just do a PowerPoint?" I felt that kind of resistance. And then my [classroom MT students] were great. They loved the stuff that we did.
Student engagement differed by classroom design	***Sub-theme 1: student engagement with classmates*** • That's one thing I noticed very quickly, is that students, as soon as they go in [classroom MD] they move themselves in rows; they move out of the pods into rows. In [classroom MT], when I would walk in, it was very noisy; students were talking and there was a sense of community in [classroom MT]. In [classroom MD], you can hear a pin drop. [Interviewer: All semester?] Yeah, all semester long. Because they put themselves in rows, and they were on their phones. [Interviewer: Do you think there was a difference between the groups of students in those two rooms?] Possibly. I thought about that: What would happen if the students in [classroom MT] were in [classroom MD] and how would they respond and would they put themselves in rows? I don't know. I would you try, you know, every time I'd walk in, I'd be like "C'mon y'all, put your phones up! Talk! Have a conversation. And I would do some more icebreakers and that kind of thing. And once I forced them into groups, they were - it's not like they didn't like each other, you know - they would work together and they were friendly. When we went out into the community and did our service learning, they were friends that way. We went to the gym

	and did some things and they all would cut up with each other. But as soon as we went back into the room – rows and phones. It was very interesting to me. • It was eerily quiet in there every time I walked in [classroom MD]. Just like, 'c'mon, guys, let's have a conversation, let's chat.' […] And I would ask them, 'what do y'all think about the chairs and stuff', and a lot of them would say "I don't know", "they move so easily." But every time they would just move them back into the rows [after group work]. They were so hesitant to keep them in the pod looking at each other. I think they felt awkward; like, if they kept them like that somebody would think that they were weird. Like, "why are you sitting so close to me? why are you looking at me?" you know? But in [classroom MT], they're forced to stay like that. [Interviewer: Because you've got a defined space and depending on the number of students at the table, they may have to be in each other's space?] Yeah! Right! And there's nothing they could do about it. Somebody can't be like: "move out of my space, bro". You know, cause we forced them to be that way. • I definitely like [classroom MT] better just because it forces, they can't move their physical body, they're stuck [laughing] looking at each other, you know? [Interviewer: They're a captive audience?] Yeah! So, they have to work together, and they have to - whether they want to or not - they're looking at somebody's face, and so when I say, "Alright, work in groups", they're there. And, if you have somebody that's chatty, or somebody who likes working in groups, sometimes they'll pull those people - those introverts - in because they're sitting there and they're right next to each other. In [classroom MD], because the desk moves so easily, someone that is introverted and doesn't like to work within groups can easily move themselves out of that group structure. ***Sub-theme 2: student engagement with instructor and instructional activities*** • Jigsaw is where you take a chapter and they start in home groups and then in those home groups they pick an expert group and then they go to the expert groups, become experts, and then come back to the home groups and teach. […] I definitely felt like the group in [classroom MT] did better with that than [classroom MD]. So, in one way that I measured that really is kinda subjective actually; but, they take a quiz at the end to make sure that they got out of it when I needed them to. And the [classroom MT] group had to take the quiz in the next class time: We did it on Tuesday and they had to take the quiz on Thursday after they finished teaching. So, that class was at 9:30; I think we took the quiz at 10:00, on Thursday. [Compared to] the [classroom MD] class: We took the quiz on the same day. And so that kinda tells me that [...] I'm just kind of measuring subjectively, that they took so long teaching that they were really into the assignment and wanted to teach more, talk more about their expert areas. I facilitate; I walk around and give some questions and kinda play the devil's advocate a little bit with some topics they are really talking about. In [classroom MD] I couldn't even, it was hard for me to get them going, you know? They just answered the questions on the paper and that was it; they were ready to take the quiz. […] Definitely their participation and engagement was less [than classroom MT]; I felt like I had to really prod them more and give them more questions to think about. And, even by doing that, they were still ready to take the quiz at the end of the day. • I do kind of just go back to the way the room is designed. I think in [classroom MD] it was just so easy for them to become unengaged and like in [classroom MT] if they're on their laptops, it's very easy to walk around the perimeter while I'm talking and check out what they're looking at on their laptop and for them to easily "X" out […] But in [classroom MD], because of the arrangement of the desks and they were so in disarray, it was really hard for me to get back there while I was talking, and check out what was going [on student laptops].

Barriers to implementing active learning methods	• So, for example, in the fine motor, I do a fine motor lab where I bring in a bunch of different toys and activities that we do with preschoolers to elicit fine motor control. In [classroom MT], it's really easy because we have a bunch of flat surfaces. We do different activities with Playdough and things like that. So, it makes it really easy. But, in [classroom MD], because the desktops are small - which would be the case with any desk, you know - I had to really think through, how can I kind of put two desks together and, because they move so easily, one of the activities is Jenga - we do that often with kids that are struggling with control of their wrist and elbow - so we really had to think through where to put that because you can't put that on a moving surface. So, it's just things like that. Nothing huge. • I like that it's easy to walk around the perimeter of [classroom MT], as opposed to [classroom MD] which feels messy. I like the structure in [classroom MT]; I'd never moved the tables just because I liked knowing, I plan ahead and so in my mind I plan, this is what I'm doing. I almost plan out how I'm gonna be walking around the classroom. Whenever I'm walking around and visiting the tables, like I kind of plan ahead and know that this is the path I'm gonna to take. And, so in [classroom MD] nothing can be planned ahead because it's really messy in there; the desks are in such disarray. [Interviewer: You never know where they're going to be?] Yeah. [Interviewer: So, do you think that makes it harder to reach every group equally in [classroom MD]? Yeah, because you have to really, you know, I tripped a couple of times because somebody would like get up and push a desk, because they are so easily moveable, they would like push it as they were walking and it hit me, or it would be right behind me and I wasn't expecting it and I would trip over it. So different things like that.

Table 4. ***Frequencies and Proportions of Three Categories of Observed Student Engagement Behaviors from STROBE Observational Survey***

Learning Space	Lesson	Student-to-student[a]		Student-to-instructor[b]		Self-engagement[c]	Total
		Speaking	Listening	Speaking	Listening		
Classroom MD[d]	Lesson 1	23 (18.4%)	18 (14.4%)	6 (4.8%)	48 (38.4%)	30 (24.0%)	125
	Lesson 2	25 (14.0%)	39 (21.9%)	10 (5.6%)	49 (27.5%)	55 (30.9%)	178
	Lesson 3	51 (23.5%)	33 (15.2%)	24 (11.1%)	41 (18.9%)	68 (31.3%)	217
	Total	**189 (36.3%)**		**178 (34.2%)**		**153 (29.4%)**	**520**
Classroom MT[e]	Lesson 1	21 (15.9%)	25 (18.9%)	10 (7.6%)	48 (36.4%)	28 (21.2%)	132
	Lesson 2	35 (18.7%)	55 (29.4%)	3 (1.6%)	48 (25.7%)	46 (24.6%)	187
	Lesson 3	31 (20.9%)	16 (10.8%)	8 (5.4%)	38 (25.7%)	55 (37.2%)	148
	Total	**183 (39.2%)**		**155 (33.2%)**		**129 (27.6%)**	**467**

[a] Observed students were visibly engaged with another student or in a small group of students during team learning activities. [b] Observed students were visibly engaged with the instructor either during lecture or interacting with the instructor when working in small groups during team activities. [c] Observed students were reading, writing, or otherwise not visibly engaged with other students or the instructor. [d]MD = active learning classroom with mobile desks group. [e]MT = active learning classroom with mobile tables group.