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Technological Innovation or Educational Evolution? A Multi-disciplinary Qualitative Inquiry into Active Learning Classrooms

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Abstract: In recent years, many institutions have transformed traditional classrooms (TCs) into technology-rich active learning classrooms (ALCs) to accommodate the pedagogical concept of "active learning". In order to investigate the impact of ALCs on teaching and learning, we observed an instructor teaching in an ALC for an entire academic year, audio/video-recorded every class and took field notes. A focus group discussion was conducted with faculty from six allied health disciplines who taught weekly classes in the ALC and an online survey was distributed to students who took those classes. Data was then analysed using a qualitative constant comparative method (CCM). Findings indicated that the ALC generated greater teaching and learning enjoyment, deepened engagement, amplified interaction, enhanced group activity efficiency and fostered the development of creative ideas. All these features were interrelated and created a synergistic effect on student learning.

Keywords: active learning classroom, technology, engagement, interaction, group activities, creativity,

Introduction

Educators agree that the goals of education should be to engage and inspire students, as well as motivate them to learn content and necessary skills (Auster & Wylie, 2006). Researchers have criticized traditional teaching approaches as they were oftentimes considered autocratic and failed to take student learning into account. The teachers determined what, how, and when students learned and students just sat and passively listened to the teachers (Bonwell & Eison, 1991; Chickering & Gamson, 1987; Dupin-Bryant, 2004; M. R. Gregory, 2002; Laurillard, 2002; Lowman, 1984; Penner, 1984; Steuter & Doyle, 2010; Umbach & Wawrzynski, 2005).

One strategy to remedy the inadequacy of traditional teacher-centered passive approaches is active learning. Active learning has been described as both involving students in doing things but also in thinking about what they are doing (Bonwell & Eison, 1991, p. 19). However, the traditional brick-and-mortar classroom often does not create an environment that promotes a student's engagement in learning (Thomas, 2010, p. 503). Effective interaction and group activities, the key elements of active learning, are not conveniently accomplished around fixed

tables and chairs. When promoting active learning, flexibility in the learning environment is beneficial.

In 2007, Michael Wesch, a cultural anthropologist and media ecologist at Kansas State University, asked his 200 college students, "What is it like being a student today?". Based on the feedback, Wesch and the students made a video called "A Vision of Students Today" (Wesch, 2007) and posted it on Youtube. It soon became one of the top hits on the web with millions of views. This video accurately captured the typical characteristics of students today. "I will read 8 books this year, 2300 web pages and 1281 Facebook profiles." "I spend 2 hours on my cell phone." "I bring my laptop to class, but I'm not working on class stuff." These plain facts are thought-provoking to educators. No doubt that students today are no longer the same as those prior to the invention of computers, Internet, and smart devices. In the traditional classroom, students sit in rows taking notes on paper while teachers stand on the podium writing on the chalkboard. Teachers are the students' primary source of knowledge. Today, in the era of information technology, students can search for information on any given subject in a matter of seconds due to the ubiquitous use of laptops, tablets, and smart phones and the omnipresent access to Internet. Students no longer browse through bookshelves in the library, searching for information to finish an assignment. Universities are challenged with the urgent need of incorporating information technology into the learning environment to accommodate this new generation's learning habits (Long & Ehrmann, 2005; Oblinger, 2005).

Many institutions in higher education have taken the initiative to transform traditional classrooms (TCs) into technology-rich active learning classrooms (ALCs) to meet the needs of current learners. Leading examples include North Carolina State University (NCSU)'s SCALE-UP project (Robert J. Beichner & Saul, 2003; Robert J. Beichner et al., 2007; Robert J. Beichner, Saul, Allain, Deardorff, & Abbott, 2000), Massachusetts Institute of Technology's TEAL project (Dori & Belcher, 2005; Dori et al., 2003), and the University of Minnesota's Active Learning Classrooms (ALCs) (Brooks, 2011, 2012; Brooks & Solheim, 2014; Walker, Brooks, & Baepler, 2011; A. L. Whiteside, Brooks, & Walker, 2010). These ALCs typically feature multiple flat-panel screens/projectors, movable tables and chairs, and portable device-based technology that allow flexibility, connectivity, smooth interaction, and dynamic collaboration. With the advent of bringing your own devices for technology-rich instructions, both teachers and learners are able to create a collaborative learning environment.

Consequently, research on ALCs has drawn the attention of educators in the last few years, though there is a limited number of peer-reviewed scholarly articles. Research in ALCs has been conducted in various disciplines such as finance, biology, physics, and chemistry (Baepler, Walker, & Driessen, 2014; Robert J. Beichner & Saul, 2003; Robert J. Beichner et al., 2007; Robert J. Beichner et al., 2000; Brooks, 2011; Brooks & Solheim, 2014). We were not aware of published studies of active learning classrooms in allied health educational settings. Moreover, most of the existing research focused on quantitative results such as course grades, attendance rates, graduation rates, and failure rates. Very little has been reported on findings from a qualitative approach, especially from both faculty and students' perspectives. A more comprehensive qualitative investigation is needed to further explore the effectiveness of active learning spaces and to provide a more holistic picture of the impact of active learning classrooms.

In 2014, a school within a southeastern academic medical center renovated a traditional classroom and made it into a technology-rich active learning space. The space was aptly renamed the Collaboratory (see Figure 1). It featured 12 large interconnected flat screens and a wall projector that provided an unobstructed view of instructional content from anywhere in the room.

The room was equipped with semicircular and rectangular movable tables with access to power outlets and smart device hookups allowing easy peer interaction and screen sharing among in-room and personal devices. Individual swivel chairs with built-in work surfaces and storage in the tripod base permitted students to orient themselves in any direction for interactive learning. Both large and small portable white boards on rolling stands supported creation, sharing, and display of individual or group work. Within this space, instructors could easily reconfigure from lecture to team work, group presentations, or individual work. Students could quickly huddle or break out, based on the nature of classroom activities.

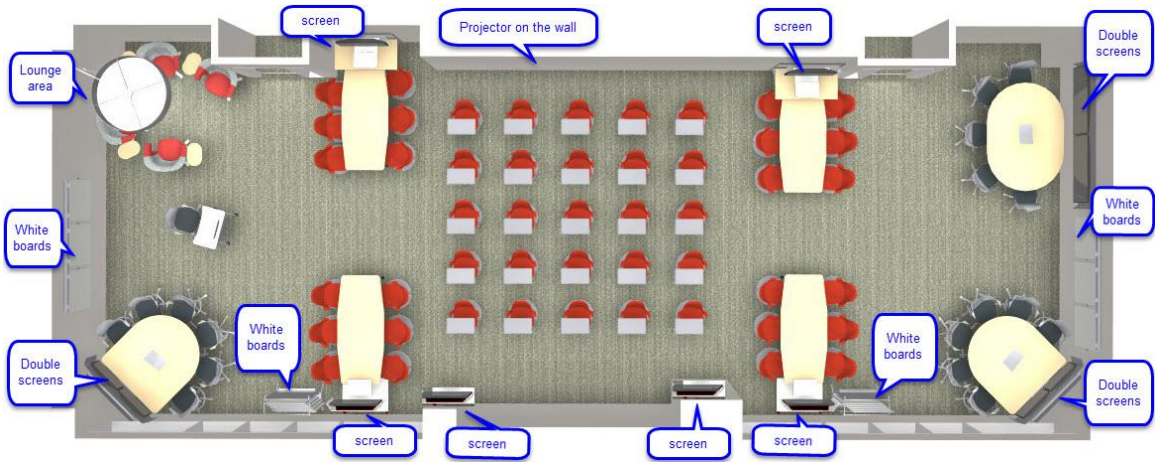


Figure 1: Physical Design of the Active Learning Classroom (Collaboratory)

Given the new learning space, the current qualitative study set out to investigate the impact of this ALC on teaching and learning. We examined activities in the ALC to discover what was taking place in the ALC and how the room affected teaching and learning, and how faculty and students perceived the educational effects of the ALC. Explicitly, our research questions include: 1) How did the Collaboratory contribute to student learning? 2) How did the Collaboratory influence teachers' choice of instructional strategies? To answer these questions, we conducted classroom observations for an entire academic year, held a faculty focus group discussion and distributed student online surveys to gather multifaceted data in hopes of gaining insights into ALCs and providing empirical evidence for future pedagogical reform and classroom redesign.

Literature Review

Active Learning

Educational research since the 1980s has clearly pointed out the inadequacy of the traditional teaching approach and illuminated the need to take student learning into account (Bonwell & Eison, 1991; Laurillard, 2002; Lowman, 1984; Penner, 1984; Steuter & Doyle, 2010; Umbach & Wawrzynski, 2005). Student learning is, rather than a passive action of knowledge acquisition, an active and constructive process where students contextualize and construct new knowledge through prior experiences and social interactions (Piaget, 2013; Vygotskiĭ & Cole, 1978). John Dewey suggested that students should not be perceived as passive recipients of knowledge, instead they should apply knowledge using independent judgement, and be capable of democratic collaboration (M. R. Gregory, 2002). However, in teacher-centered traditional teaching, learning

was controlled and directed by the teacher. Students often just sat and passively listened to the teacher (Chickering & Gamson, 1987; Dupin-Bryant, 2004).

Within this context, increasingly more attention has been paid to the concept of active learning. The term "active learning" was first noted in the literature in the 1980s (AAC Task Group on General Education, 1988; Adler, 1982; Chickering & Gamson, 1987; Cross, 1987; National Institute of Education, 1984; Ryan & Martens, 1989). Alder argued, "All genuine learning is active, not passive. It involves the use of the mind, not just the memory. It is a process of discovery in which the student is the main agent, not the teacher" (p. 50).

Since then, a growing body of research supports positive outcomes associated with active learning. Gibbs (1992) believed that when the learning environment was interactive, students were more intrinsically motivated to comprehend what they were learning and therefore tended to gain deeper understanding of the subject matter. Hake (1998) found that students gained significantly more knowledge from classroom use of interactive-engagement methods than the traditional practice. In a longitudinal study conducted by Felder, Felder, and Dietz (1998), chemical engineering students taught by an active and cooperative learning approach outperformed their traditionally-taught peers in both knowledge retention and graduation rates. Chapman and Belmings' (2006) quasi-experimental design compared biochemistry students taught by lecturing, group dynamics, and assignment of students to heterogeneous homework groups (treatment group) with those taught in the traditional manner – lecturing only (control group). The results revealed a 23% increase in knowledge retention by the treatment group. Due to the promising outcomes from active learning, many institutions are investing in transforming their traditional classrooms into active learning spaces to support this teaching approach as shown below.

Active Learning Space

When making the shift from a traditional teacher-centered approach to the student-centered active learning approach, a traditional classroom design is not effective, as fixed rows of tables and chairs do not encourage student engagement in learning (Thomas, 2010). Many institutions are leading the efforts of repurposing traditional classrooms into new technology-rich learning spaces. Primary examples that reflect these efforts in the field are North Carolina State University (NCSU)'s SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Physics) project, Massachusetts Institute of Technology's TEAL (Technology-enabled active learning) project, and the University of Minnesota's Active Learning Classrooms (ALCs).

The SCALE-UP project (Robert J. Beichner & Saul, 2003; Robert J. Beichner et al., 2000) was created to establish a highly collaborative, hands-on, computer-rich, interactive learning environment for a large-enrollment introductory physics course. The SCALE-UP classroom utilized round tables, comfortable chairs, a rectangular instructor station with computer and video presentation system, projectors, laptops, large white boards, and a wireless microphone. Basic course content was delivered through the web. Class time was devoted to difficult problems through hands-on educational activities. Results showed that the SCALE-UP students outperformed their peers in problem-solving, conceptual understanding, and even attitude development. They also demonstrated increased class attendance rates and lower overall and at-risk student failure rates. So far, over 250 institutions in the U.S. and more than 30 universities or colleges across the globe have adopted the SCALE-UP approach (Physical Education R&D Group, 2011).

Developed by the Massachusetts Institute of Technology, TEAL project aimed to increase students' conceptual understanding of physics and decrease failure rates (Dori & Belcher, 2005; Dori et al., 2003). The physical design of the classroom featured movable round tables and comfortable chairs, and multiple large display screens on walls. Teaching activities included a mixture of presentations, group-based desktop experiments, web-based home assignments, and collaborative exercises. Students of TEAL demonstrated higher scores and significantly improved conceptual understanding when compared to peers taught in the traditional lecture setting.

Based on the results of SCALE-UP and TEAL, the University of Minnesota created Active Learning Classrooms (ALCs) that offered faculty and students an interactive and flexible learning environment. The design of the ALCs featured a 360-degree wall-mounted glass-surface marker board, multiple flat-panel projection systems allowing content to be displayed from any laptop, a centered teaching station for master control of physical facilities, and round tables. The relationships of space and student learning, space and pedagogy, space and behavior (Brooks, 2011, 2012; Walker et al., 2011) were explored. Results demonstrated positive impacts of ALCs on course grades, graduation rates, attendance rates, failure rates, and knowledge retention. However, qualitative investigation on what actually happened in the ALCs, how this type of room affected faculty teaching and student learning, and what educational effects the room produced are still lacking in the literature. This study intends to bridge the gap and provide educators with a more realistic and comprehensive view of ALCs.

Methods

Qualitative Inquiry

A qualitative interpretive design was chosen to investigate the impact of an ALC on teaching and learning. Unlike experimental research that deductively tests hypotheses, qualitative research involves the use of interpretive techniques to seek understanding of a phenomenon through participants' perceptions and experiences. Findings are typically derived inductively from data gleaned in the form of themes, concepts or theories (Merriam, 2009, pp. 13-16). In this case, we were interested in understanding the lived experiences of both teachers and students in this new active learning environment. We employed the most well-known data collection strategy – triangulation –to increase internal validity of the study (Merriam, 2009, p. 215) and to obtain a complete picture of the day-to-day educational experiences in the active learning classroom. Audio-/Video-taped observations were recorded for a year with associated field notes. A focus group discussion was conducted with faculty who taught in the ACL, and students who have attended class in the ACL completed a survey with open-ended questions. We determined that an interpretive paradigm provided the most effective method of inquiry to conduct this research.

Participants

In order to find the best qualifying class observation candidate, we examined into the schedule of the ALC from the past academic year to see who had taught there on weekly basis. Five instructors were identified. Among those, only one was scheduled to teach two consecutive courses (Dental Radiology I and II) in the Collaboratory in the academic year (2015-2016). We chose this particular one to be our class observation participant. The rationale was that observing two consecutive courses taught by the same instructor to the same students would provide us with twice

as many opportunities to watch the happenings in the Collaboratory and double our data collection. Towards the end of the academic year, we invited the five instructors mentioned above and three more who had had experience teaching allied health courses in the Collaboratory, a total of eight, to a focus group discussion. Also 275 students of the above eights instructors were invited to participate in an online survey that included open-ended questions.

Data Collection

Upon receiving Institutional Review Board approval for the study, the first author conducted classroom observations throughout the academic year, from which she gained 19 audio-/video-recordings of each class, 95 pages of unstructured field notes of verbal or non-verbal happenings in the classroom, and a manual transcript of 100,000 words in a Word document.

Towards the end of the academic year, we conducted a focus group discussion with eight instructors. The discussion was semi-structured and consisted of thirteen questions regarding lecturing, students' focus and attention, classroom cohesiveness and advice-seeking. These questions were adapted from the faculty focus group discussion guide used by the Learning Spaces Research team at the University of Minnesota (Brooks, 2011, 2012; Brooks & Solheim, 2014; Cotner, Loper, Walker, & Brooks, 2013; Walker et al., 2011; A. Whiteside, Walker, & Brooks, 2010; A. L. Whiteside, Jorn, Duin, & Fitzgerald, 2009). The discussion lasted two hours and the manual transcript contained 18,000 words in a Word document.

In the meantime, we distributed a 25-question online survey adapted from Park and Choi's study *Transformation of classroom spaces: traditional versus active learning classroom in colleges* (2014) to 275 students who took classes from the above faculty in the Collaboratory. One open-ended question [Do you prefer to take classes in the active learning classroom (ALC) or traditional classroom (TC)? Explain your answer] in the survey was included for analysis in this paper. Approximately 70% of students (n=193) responded to this open-ended question.

Data Analysis

We employed a constant comparative method (CCM) to analyse data from the faculty focus group discussion and student open-ended question. This methodology is often used to compare data from open-ended questions, interviews or focus group discussions (Glaser, 1992; Glaser & Strauss, 1967; Strauss, 1987). We followed a defined process (Savin-Baden & Major, 2013) by first identifying the most frequently used words and phrases to develop major categories. These were then identified in the transcripts and open-coded. Next, a constant comparison of codes and quotes was conducted to find consistencies and discrepancies. We examined the recurring codes and refined initial categories. Once those initial categories were developed, we checked against our class-recording transcripts and field notes to confirm the validity of these categories. Finally, five themes were determined to be the central focus of the subject matter.

Trustworthiness

To ensure trustworthiness of the study, we used the triangulation strategy in our data collection. We collected data from three different channels: field notes from class observations, a faculty focus group discussion and an online student survey. All three sources of data were brought together to elaborate and corroborate the research in question. Also multiple investigators were involved in

the data analysis. The first and second author independently analyzed the data. The third author reviewed their results and discussed all discrepancies with the other two. All three authors agreed on the final five emerged themes presented in this paper.

Organization of Results

Analysis of data resulted in the development of five interrelated themes. These themes will be presented as they emerged from the data along with supportive narrative.

Results

The result section is organized by themes that emerged from the data analysis process. The five overarching themes were positive environment, depth of engagement, classroom interaction, efficiency of group activities, and development of creativity. Excerpts selected from the transcripts are provide as representative quotations to support each theme represented.

Positive Environment - The physical features of the Collaboratory created a positive environment for teaching and learning.

Physical features of a learning environment are an integral part of teaching and learning. In this study, we observed that the physical features of the Collaboratory including – open layout, comfortable chairs, spaciousness, and brightness of furniture colors have helped make people feel more welcomed and relaxed.

One instructor brought up an example of new student orientation in the Collaboratory. She said:

> When we oriented to the DHA [i.e. Doctor of Health Administration] program, we did our orientation up there and what I found was that because of that setting, the way we had our chairs set up, you know, I was meeting people I have never met before and so that was a good way to kind of break the ice, a little more welcoming environment, again, rather than staring at the back of somebody's head, to, to get to know somebody.

Students responded in a similar fashion. They made comments like:

> (I prefer) ALC. I like the change of scenery, the more technologically advanced seating and slide presentation. It is great for group work and seems more relaxed and self-driven than traditional classrooms.

Student Engagement - The design of the Collaboratory allowed mobility and promoted student engagement.

Student engagement is of global importance in any education setting. The typical traditional classroom design contains rows of tables and chairs, all facing the lectern in the front. Many have tables and chairs bolted down to the floor and nothing is movable. In the Collaboratory, however, every piece of furniture is movable. Workstations are spread all over the room facing different

directions so students no longer have to squeeze in between tables and chairs to get to a seat and there is plenty of space for everyone to move about. One instructor said:

> We don't even talk in the same spot. We might be in the corner, we might be in the front, we might be behind them in a different corner. There is no hierarchy, you know, there is no the front and the back, or the sides… And they are committed. We don't have a lot of coming and going like we are in in a regular classroom… I mean even because it's more open, you think they would come and go more, they don't because they are engaged. So I just, I feel like they are really with you more.

Students' responses echoed instructors' observations. They believed that they could stay engaged in the Collaboratory. Supportive quotes include:

> (I prefer) active (learning classroom) because it keeps me engaged and I'm not just sitting there listening to someone talk for hours. I can be moving and talking and thinking out loud.

From the year-long classroom observations, we noted that the majority of students, rather than passively listening to lectures or doing things unrelated to class, were constantly found underlining or highlighting handouts, taking notes, asking or answering the instructor's questions, which further supports the theme of student engagement.

Classroom Interaction - The non-hierarchical design of the Collaboratory democratized learning and enhanced classroom interaction.

Enhancing classroom interaction has been a major focus of many educators. Since the Collaboratory does not have a focal point, it does not present the hierarchical structure as the traditional classrooms do. Instructor comments included:

> I think what's important about this space is that, I am going to use word that, I don't know, I just feel like I really want to say this, it democratizes learning. I used to teach in an environment where you had students line up at their desks looking to getting help. You are like 'how inefficient is this?'

With the freedom to move about in the room due to the mobility of furniture and open layout of the Collaboratory, the students felt that they could interact more with each other during class. Typical quotes supporting this position include:

- I can interact more with my classmates and the material, I get more work done, and I learn better by doing, so working on projects in class helps me learn the material better.
- ALC (allows for) more discussion and more interaction with other students and teachers, which is a critical component in the future setting of our career.

Examples found from video-recording transcripts and field notes fortify this finding. In the classroom, we could see how human to non-human (e.g. class content) interaction was

accomplished through the use of advanced technology in the room. Classroom content was often projected on all twelve screens to create an uninterrupted view from anywhere in the room. The instructor used an iPad to control or give control of screens. On many occasions, she asked students to google the topic of interest and gave students control of screens so that they could share, discuss and present what they had found on the topic from their smart devices. They also used Canvas, tutorial videos, and emails for additional virtual interaction. Human-to-human interaction was demonstrated through group discussions, role-plays, group presentations, and peer teaching. For example, during one class, the instructor divided students into four groups and asked each group to create role-plays of good and bad examples on four respective topics – verbal communication skills, non-verbal communications skills, facilitation skills and listening skills. Googling of terms or similar examples was encouraged. The field notes suggested that 'the room was full of laughter. The students were engaged…even the ones who usually don't look (at the instructor) were engaged.'

Group Activities - The Collaboratory provided students with a more effective workspace for group activities than traditional classrooms.

Effective learning cannot be accomplished without working with peers in group activities. Traditional classrooms oftentimes fail to provide an effective workspace for the implementation of group activities. Both faculty and students in this study agreed that group activities work very well in the Collaboratory. One instructor mentioned that they often broke out into small groups for activities, and she said:

> Once we got in our small groups, it was like everything else, we would just totally (have) blended out and we were just totally into what we were working on and that room fit a lot of folks in it, and everybody was engaged in their group, so I think the design helped in that matter.

Many students' responses indicated that they preferred the Collaboratroy just because how easy group activities could be executed, mainly due to the presence of advanced technology.

> If working in groups, I prefer to work in the active learning classroom. It's easier to break into groups, and we can all look at the monitor (that the computer is hooked up to) while one person is working on the computer instead of everyone hovering around the computer to look at the screen. Also, at some areas you can add two computers if there are two monitors which is great when working on research projects.

The example presented above under classroom interaction is also a prime example of group activities taking place in the Collaboratory. They are the further proof of the effectiveness of the space for group activities.

Creativity - The environment of the Collaboratory fostered the development of creativity.

Creativity was placed on the top of the learning pyramid and considered as the ultimate learning objective, according to Bloom's Taxonomy (Anderson et al., 2001). In this study, instead of

lecturing, quite a few instructors mentioned that they used the Collaboratory as an opportunity to involve students in higher-order thinking. One said,

> The environment itself, besides the change from the rows, you know, a lot what ask them to do in there is to think and create something. And so, um, it's also, we really stress these, the team, because in, that's a huge part of our content as you each have something different to contribute to this team, to think outside the box for these research projects.
> The students found the Collaboratory conducive to creativity as well. One student said, (I prefer) ALC, because the atmosphere is different. There is a creative vibe in the room.

To support this finding, we found a noteworthy example from the class observations. During a peer teaching activity, one group creatively explained magnification and distortion of x-ray images through shadow casting. They used the flash light feature on the cell phone to cast light over a blank white board and vividly demonstrated the relationship among positioning of x-ray tube, distance and x-ray images.

In summary, both instructors and students enjoyed the welcoming and relaxing environment of the Collaboratory. They all believed that the Collaboratory promoted engagement, amplified interaction, enhanced group activity efficiency, and fostered the development of creative ideas.

Discussion

Results from the current study indicated that the physical features of the Collaboratory created a positive learning environment for both the faculty and students. According to Graetz (2006), the physical features of learning environments could affect learners emotionally and lead to important cognitive and behavioral consequences. Environments that induced positive emotions facilitated learning, whereas noisy, crowded and uncomfortable spaces could cause discomfort and interfere with learning. Williams, Childers, & Kemp's (2013) study concurred with Graetz' statements and the current study's findings. They discovered that a positive relationship existed between the physical surroundings of the classroom and students' positive emotions in the classroom. Also in the same study they revealed that positive emotions in the classroom are positively related to student academic success. Since the Collaboratory induced a positive environment for both the faculty and students, we can infer that the learning environment of the Collaboratory should facilitate learning and potentially contribute to future learning success.

The results of the current study also indicated that students appeared to stay more engaged in the Collaboratory than they normally would in the traditional classroom, which is in line with Smith and Cardaciotto's finding (2011). Student engagement represents time and effort students devote to academically meaningful activities that are conducive to learning and personal development, and what institutions do to facilitate students' participation in such activities (Delialioğlu, 2012; Kuh, 2009). Student engagement has emerged as a major focus of educational objectives in higher education globally (Harper & Quaye, 2009), as positive correlations have been identified in previous studies between student engagement and student satisfaction levels of their academic experiences, drop-out rates, learning outcomes and overall educational quality (Coates,

2008; Greenwood, Horton, & Utley, 2002; Legters, Balfanz, & McPartland, 2002; Perie, Moran, Lutkus, & National Center for Education Statistics, 2005).

As mentioned previously, the year-long classroom observations showed that the majority of students, instead of passively listening to lectures, were often found underlining or highlighting handouts, taking notes, asking or answering the instructor's questions. According to the ICAP (Interactive, Constructive, Active and Passive mode of engagement) Framework proposed by Chi & Wylie (2014), passively listening is categorized as a Passive Mode of Engagement; underlining or highlighting handouts, taking verbatim notes an Active Mode of Engagement; asking and answering questions are all Constructive Modes of Engagement. They believed that passive modes of engagement produced only minimal understanding of knowledge, whereas active modes induced shallow understanding and constructive modes generated deep understanding and potential knowledge transfer. The higher level of student engagement in the Collaboratory should contribute to deeper understanding of subject matter than habitual passive learning in traditional classrooms.

Results of this study also suggested that the non-hierarchical design of the Collaboratory was instrumental in enhancing classroom interaction, which supports Brooks' study finding that class discussions occurred 48% more in the ALC than in the traditional classroom (Brooks, 2012). As stated previously, human and non-human interaction was mainly accomplished through the use of advanced technology in the room, and human-to-human interaction was demonstrated through group discussions, role plays, group presentations, and peer-teaching. Based on the ICAP Framework by Chi & Wylie (2014), all those interactive examples were considered Interactive Modes of Engagement that should produce the deepest understanding and the potential to innovate novel ideas. Enhanced interaction in the Collaboratory should further deepen an understanding of the course content and lead to potential innovations.

The examples of interactions, discussed within the classroom interaction theme, are also prime examples of group activities taking place in the Collaboratory. The result of the current study indicated that both instructors and students expressed their preferences over this active learning space and were in consensus that the space had improved the efficiency of group activities. Group activities have been extolled in higher education as an effective strategy to improve engagement and promote interpersonal, decision making, problem solving, time management, and critical thinking skills (Bonwell & Eison, 1991; Johnson, 2013; Koh, Wang, Tan, Liu, & Ee, 2009; Swaray, 2012). Positive effects of group activities have been reported in several studies. Smith and Cardaciotto (2011) reported that active learning group work contributed to greater knowledge retention and student engagement. Swaray (2012) found in his study that the majority of students (78%) believed that group activities encouraged them to work effectively with other students, which concurs with the student statements from the current study. He also revealed that students believed group activities were inspiring, motivating, and conducive to the development of work-related skills.

Creativity has gained increasing attention in education settings and has been considered as one of the most vital skills that help prepare students for future success (Craft, 2011; de Alencar & de Oliveira, 2016; E. Gregory, Hardiman, Yarmolinskaya, Rinne, & Limb, 2013). Its importance can be seen from the revised Bloom's Taxonomy that defined "creating" as the ultimate learning objective (Anderson et al., 2001). Students with creative abilities, according to Davis and Rimm (2004), outperformed students with a high IQ in lifetime achievements. In this context, nurturing creativity has become one of the most valued, though often unrealized, educational goals (Beghetto

& Kaufman, 2014). The finding from this study infers that the Collaboratory can potentially drive us closer to the fulfilment of this goal.

There are some limitations to this study. First, the study was conducted in a newly built ALC. The novelty could have contributed to some of the positive effects but may wear off with time or emergence of newer technology. Second, though the study included faculty from quite a few different disciplines, the participants were all from one school within a medical center. Existing ingrained culture within the school could have played some role in some of the study findings. Third, the study only made observations in one teacher's classes during the academic year. Future researchers are encouraged to conduct similar studies with multiple teachers from different disciplines or institutions using different ALCs, which will further enhance our understanding of active learning classrooms.

Notwithstanding these limitations, the use of several data sources including field notes from a year-long observation, focus group discussion with faculty, and student surveys, makes this study a rich investigation of the impact of the active learning classroom. All the emerged features of the ALC - greater teaching and learning enjoyment, deepened engagement, amplified interaction, enhanced group activity efficiency and fostered creativity - are synergistically interrelated and hold important implications for future pedagogical reform and classroom redesign.

Appendices

Appendix 1. Faculty Focus Group Questions.

Introduction:
Brief introduction of the researcher. Brief explanation of the current study and the purpose of the interview.

Questions:
Poll: How many total courses have you taught in the Collaboratory? What courses are they?

Lecturing Questions:
We know that the design of the Collaboratory is very different from the traditional classrooms. Students do not sit in rows at fixed tables all facing the instructor.

Q1: What in particular makes lecturing in these spaces challenging?
Q2: In your opinion, what are the biggest fixable problems with the room?
Q3: Can you articulate what is important about the active learning space?
Q4: Can you give me an example of what worked particularly well in the room?
Q5: Did the room change how you addressed your teaching objectives?
Q6: How did having a technology-enabled room – wireless access, plasma screens for every table, projection capability – prompt you to change your previous teaching practice?
Q7: Has the room and the way that you teach in it changed anything about your assessment practices? Do you do more group assessments, for example? Do you collect different data or evidence of achievement?
Q8: Generally, did the room change what you do in other classrooms? That is, did you or do you intend to carry over anything you do in the Collaboratory to teaching in more traditional rooms?

Focus and Attention Questions:
We've heard that some students have difficulty focusing on who is speaking or keeping track of what is going on. The sight lines are such that they don't always face the same direction and can lose track of who is speaking or what is being written on the board or referred to on the screen.

Q9: Did you find this to be true? How did you recognize that students were unable to focus? Do you do anything to help them with this problem?
Q10: In contrast to more traditional styles of rooms, do you find students to be more easily distracted in the Collaboratory? Again, have you tried to address this in any way?

Classroom Cohesiveness:

Q11: What was your sense of the classroom community? In your opinion, did the students in the Collaboratory seem to be more friendly or collegial with each other than in other rooms? What did you notice that would suggest this?

Advice:

Q12: What physical features of the room do you think need to be improved?
Q13: What do you wish you had known before teaching in the Collaboratory for the first time? What advice would you give instructors teaching in the room for the first time?

Appendix 2. The Impact of Learning Spaces on Student Learning Survey.
(Note: The content of this survey was delivered via an online survey tool - Qualtrics)

> Dear students,
> We would like to evaluate your satisfaction/dissatisfaction levels regarding different learning spaces (Active Learning Classroom, i.e. the Collaboratory vs. the traditional classroom) to determine whether the difference in space affects student learning.
> Thank you for your participation!
>
> ★ This survey will take you approximately 10 minutes to complete.

I. Participant information

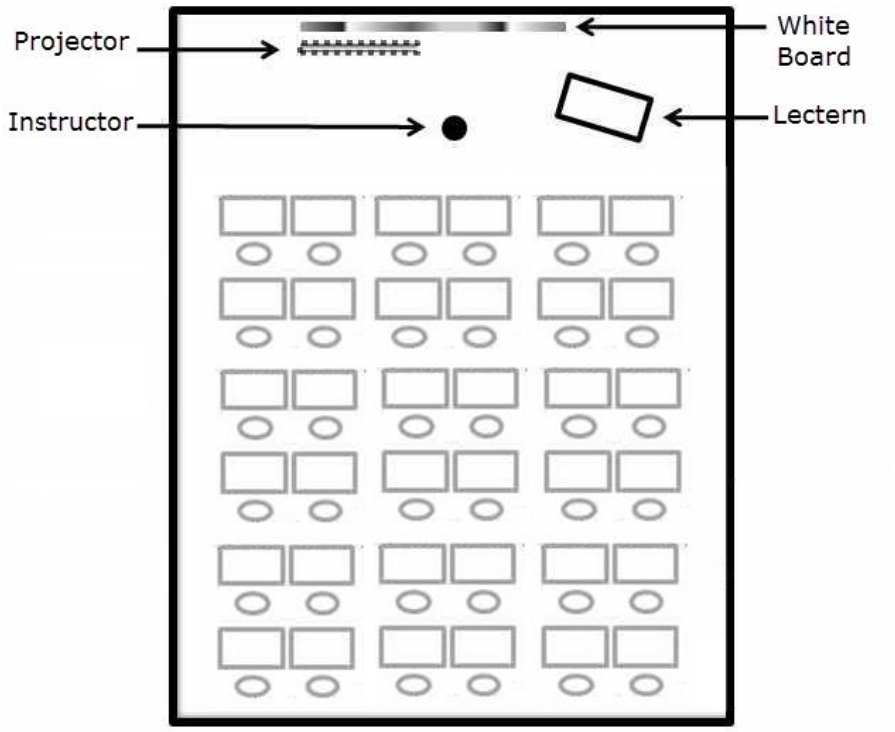
1. What program are you in? ① Dental Hygiene ( ) ② Occupational Therapy ( )
③ Physical Therapy ( ) ④ Medical Laboratory Science ( )
⑤ Radiology Science ( )
2. Gender ① Male ( ) ② Female ( )
3. Race ① White ( ) ② African American ( ) ③ Asian/Pacific Islander ( )
④ American Indian ( ) ⑤ Hispanic or Latino ( )
4. GPA: ① 2.5-2.9 ( ) ② 3.0-3.4 ( ) ③ 3.5 – 3.9 ( ) ④4.0 or greater ( )

5. Check the appropriate box.

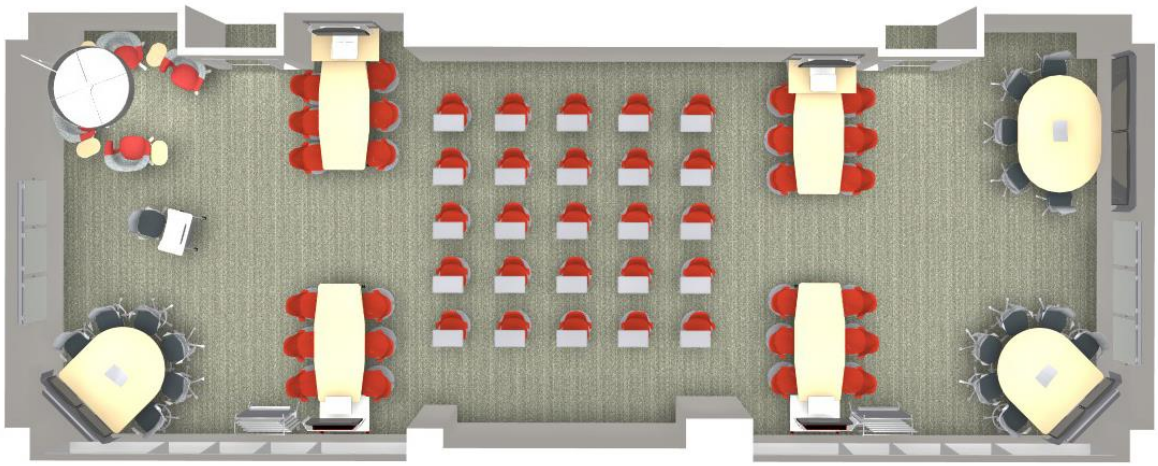
Items	Strongly disagree	Disagree	Moderate	Agree	Strongly agree
① I have strong confidence in my learning ability.	1	2	3	4	5
② I prefer assignments requiring creativity.	1	2	3	4	5
③ I am willing to raise my hands and ask questions in class.	1	2	3	4	5
④ I think gaining knowledge is more important than receiving high scores. ( ) I think receiving high scores is more important than gaining knowledge. ( )					

II. Educational effects of the active learning classroom (**ALC**) and traditional classroom (**TC**).

Design of the traditional classroom (**TC**)



Design of the active learning classroom (**ALC**, known as the Collaboratory).



The items presented in the table below intends to analyze the educational effects of ALC and TC. Please check the appropriate box.

Items	Classroom type	Strongly disagree	Disagree	Moderate	Agree	Strongly agree
1. I have a clear view of the screen from anywhere in the classroom.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
2. I prefer to seat as close as possible to the instructor.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
3. The instructor devotes more time to discussion/group activities than lecturing.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
4. I can maintain my concentration in class for a long time.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
5. It is easy to get the instructor's attention to ask questions.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
6. The learning space provides effective space for group activities.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
7. The learning space enhances the efficiency of group projects.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
8. It is easy to exchange information and share different viewpoints with other students.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
9. It is easy to interact with the instructor.	TC	1	2	3	4	5
	ALC	1	2	3	4	5

10. The learning environment is conducive to the development of creative ideas.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
11. I can retain newly taught course materials well.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
12. I have strong motivation for learning.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
13. I do things unrelated to the class (playing on the cell phone, talking with other students, etc.)	TC	1	2	3	4	5
	ALC	1	2	3	4	5
14. I feel sense of belonging to the class and have a close relationship with classmates/instructor.	TC	1	2	3	4	5
	ALC	1	2	3	4	5
15. I think class is fun and look forward to it.	TC	1	2	3	4	5
	ALC	1	2	3	4	5

III. Other questions.

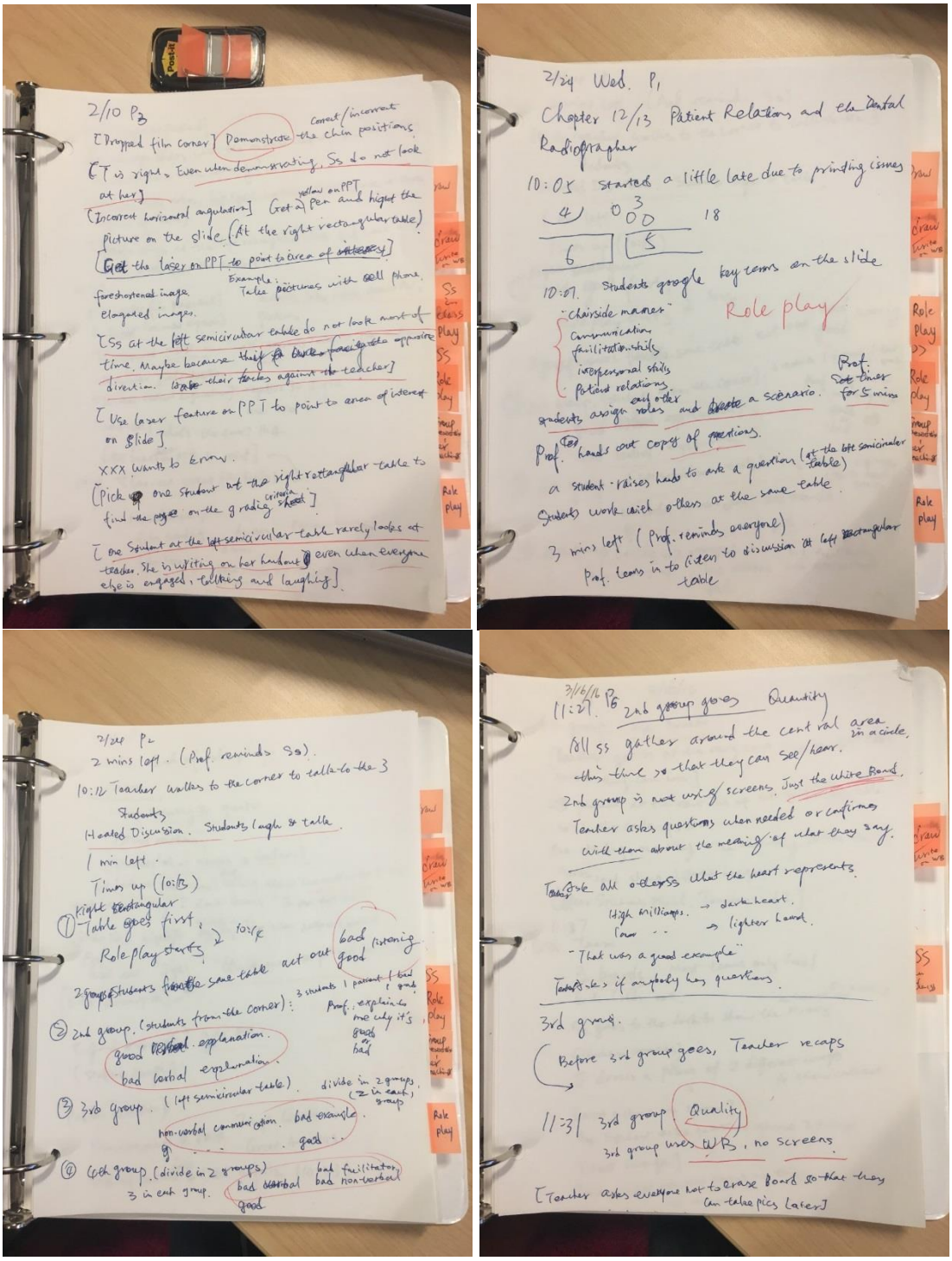
1. Do you prefer to take classes in the ALC or TC? ALC ( ) TC ( )
→ Explain your answer?
①
_____
②
_____

2. What features in the ALC do you like the best?
①
_____②
_____

3. Do you think we need to build more ALC classrooms? Yes ( ) No ( )
4. What can we do to improve your learning experience in the ALC? Any suggestions?
①
_____
②
_____

※ Thank you for participating in this survey.

Appendix 3. Sample Field Notes



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