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best practices

Technology education courses and classrooms naturally lend themselves to providing active learning opportunities for students.

by
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Educators who engage in best practices utilize a variety of instructional delivery methods to assist all learners in achieving success in concept mastery. **Varying instructional delivery methods** allows the educator to help motivate students, connect students' prior and subsequent learning, incorporate higher-level thinking and problem-solving skills into activities and lessons, and quickly assess student learning before, during, and after a lesson. Best practices help educators set expectations for completing activities/lessons/projects/units, differentiate instruction, integrate curricula, and provide active learning opportunities for students to internalize learning (March & Peters, 2008). Best practices also include classroom management, creating collaborative learning opportunities, setting transparent course expectations, enhancing students' transferability skills, creating learner satisfaction, and creating sustainable learning for students (Stone, 2004).

Students who are engaged are active learners. Employing a variety of instructional delivery methods enables educators to help students become familiar with the concept and anticipate what will be expected at the end of the lesson, activity, or unit. Engaging in the learning process through positive anticipation leads to pride in workmanship, which naturally increases active engagement. Harmin and Toth (2006) suggest that positive anticipation minimizes stress and motivates students to seek answers and not accept failure. Motivation activities provide students with positive experiences and enable them to use and enhance their **schema**, which helps pique their overall interest and knowledge.

When educators **connect students' prior and subsequent learning to the lesson at hand**, students can discover relevance in the lesson and transfer that relevance to real-world skills. For example, when technology education students are asked to calculate the mechanical advantage of a pulley system, they are more likely to **actively engage** in the process and retain the information if they realize the benefit of being able to lift more weight (load) with less effort (force) by distributing the work through a pulley. Their previous math experience enables them to perform the calculations, but knowing why the process is important and relating it to future applications and real-world situations adds value to the concept. Making the connection to students' schema provides educators with valuable information regarding how much depth is necessary for background information when introducing the lesson and how much time should be allotted for lesson completion. It also makes it easier for educators to quickly assess student learning before, during, and after a lesson. Using the pulley system example, if math pretest scores indicate that students possess the necessary math skills to calculate mechanical advantage, then the educator can begin the lesson with the how and why of the pulley system rather than including a mathematics review. During guided practice, educators can circulate the classroom, checking students' understanding. After students complete the activity, quickly assessing concept mastery is easy.

Today's students are expected to enter the workplace with necessary 21st century skills including **higher-order thinking and problem-solving skills**. To ensure student success beyond the classroom while at the same time engaging students in their own learning, educators must design lessons and activities that allow students the opportunity to practice, apply, hone, and enhance these critical-thinking skills. Technology education courses introduce and repeatedly reinforce systematic problem-solving processes, which naturally require students to demonstrate higher-order and critical-thinking skills.

Educators should **set clear expectations for activity/lesson/project/unit completion including quality of workmanship, time on task, required deliverables, due date(s), and concept objectives**. Doing so will let students know exactly what the teacher expects, how thorough they need to be, how long they have to complete the work, what they need to submit, and the due date. Then students can set personal learning goals for the assignment. Research indicates that students who set their own content learning goals form a more direct attachment to the content, take a more proprietary interest in it, pay closer attention to detail, and accept more responsibility for their successes and shortcomings, making them actively engaged in their learning.

Differentiating instruction is essential to the classroom climate and the success of all students. We are not a one-size-fits-all clothing society, nor do we all learn at the same rate in the same manner. We are uniquely different and complex! Some of us are visual learners, some of us are hands-on learners, some of us are auditory learners, and some of us are a combination of all or some of the above. Educators must continuously adapt the curriculum in different ways to meet the needs of all learners and ensure student success. For example, educators modify the content, the process of teaching, the required deliverables (outcome), and even physical factors of the environment to help students achieve concept mastery. Differentiated instruction enables students to utilize their strengths, learning styles, background knowledge, and set individual learning goals.

For students to be successful in technology education courses, technology educators must embrace **curricula integration**. Students may have fun simply building a prototype, but without also investing some scholarly effort they would be left without concept mastery and transferable skills. However, if they research inventions and innovations, collect data on market need, create and design a prototype based on market need, build the prototype, and create a slideshow presentation to present their findings to the class, they will have enhanced their learning experience. Not only would they be actively engaged in the process to achieve concept mastery, but they would have used skills from other disciplines to complete the required tasks. In other words, students would be able to create a construct or underlying understanding of the concept and add new knowledge and experiences to their schema. When students integrate curricula, they can refine their technology skills, develop research skills, realize the connectivity and interaction among disciplines, actively learn, and assume authentic responsibility.

Technology education courses and classrooms naturally lend themselves to providing **active learning opportunities** for students. According to the definition provided by North Carolina Public Schools, active learning is a process in which the students are engaged in hands-on activities rather than passively receiving knowledge. Technology education courses are designed to provide active learning opportunities that permit students to use their background knowledge to construct meaning from new ideas and concepts, while working collaboratively with others. These active learning experiences include higher-order thinking tasks such as analysis, synthesis, and evaluation. Actively engaged students study ideas, solve problems, apply concepts, construct hypotheses, and make decisions. Active learning opportunities allow students to discover meaning and organize experiences while bridging the gap between real-life work and school. Hands-on activities engage, reinforce, and extend the learning process.

From day one of the school year, **classroom management** is critical to student well-being and success. A well-managed classroom sets a positive tone for the learning environment, helping to create the class community. Technology education classrooms, with a variety of equipment and supplies, can be easily managed to operate as a fine-tuned facility. Educators need to set and communicate expectations to students, and students must clearly understand what is expected of them in the course and the classroom community. Educators need to establish safety, instructional materials, and conduct procedures/rules before students begin the course; however, procedures/rules can be added/revised as needed throughout the year as long as everyone in the learning community is apprised of the changes. Often, educators include student input when creating/revising rules of conduct so that students take ownership. All rules and procedures should be clear, concise, and attainable. Consequences for not following procedures/rules should be clearly stated, and rules and procedures should be posted and clearly visible.

Educators should be mindful to consistently enforce the established rules/procedures per the stated consequences. One very practical and versatile classroom management tool for use with a variety of problematic situations is proximity. Most of the time situations involving questionable behaviors are diffused when educators position themselves near students who may be arguing, engaging in horseplay, misusing materials/tools, or exhibiting undesirable behaviors. Another important aspect of classroom management is learner satisfaction. When educators establish a positive learning environment, they create a climate and culture in which students feel comfortable and confident while actively learning. Students are not afraid of failure and might even welcome the opportunity to rethink, reorganize, and try again. A stress-free or low-stress learning environment makes for satisfied learners, and satisfied learners are more engaged and successful.

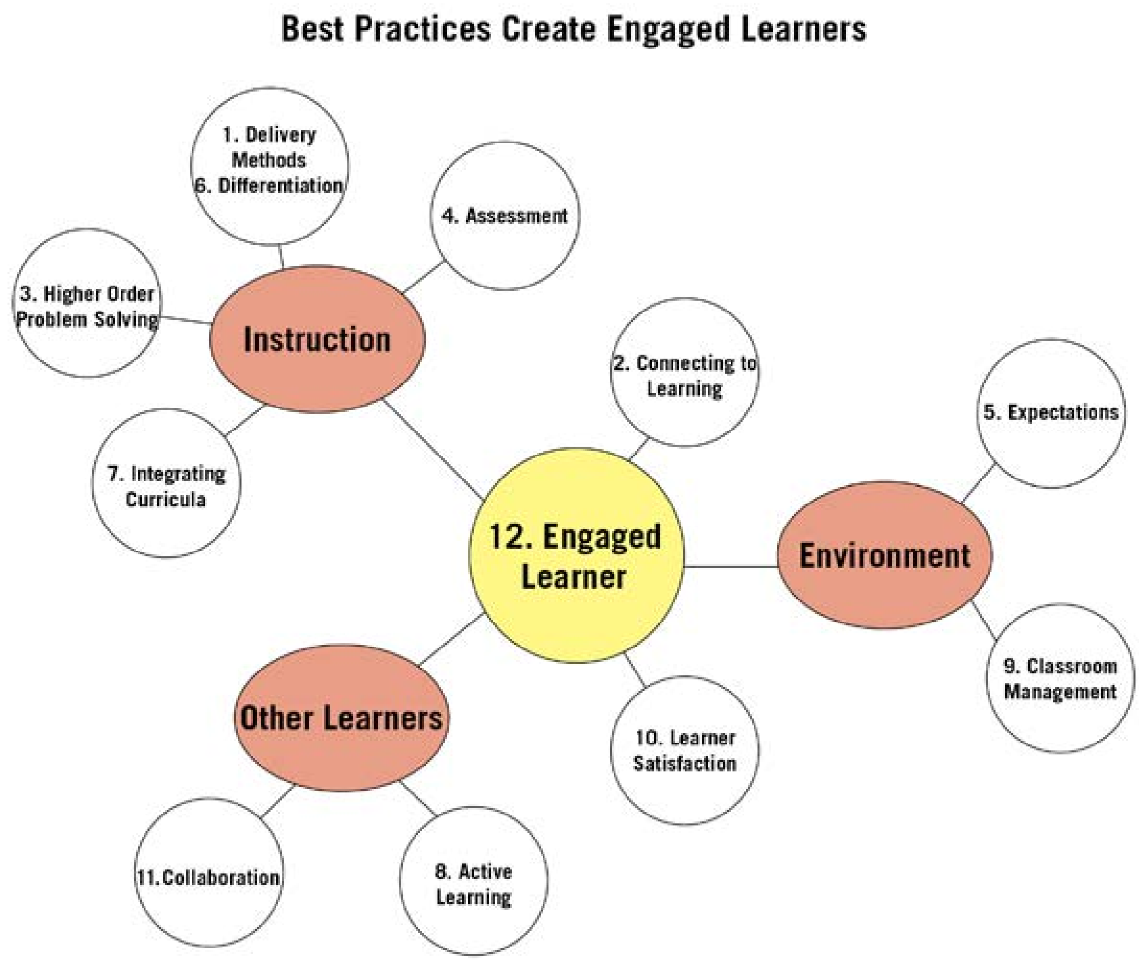
Providing **collaborative learning opportunities** for students is essential to student success, both in school and in life. Collaborative learning builds self-esteem, enhances student satisfaction, promotes a positive attitude toward the subject matter, and leads to more self-directed study and inquiry. Collaborative learning makes sense in the technology education classroom, enabling students to tackle larger and more complex activities by sharing the workload and being exposed to real-world experiences. Many activities advocated for contemporary technology education courses are designed for collaborative groups. In the workplace, collaboration is becoming more of a required skill as opposed to a desired skill. In a collaborative learning environment, educators take on the role of facilitator to ensure student success. Facilitators redirect group focus, summarize and repeat key points/comments, clarify as needed, and continually recap procedures, instructions, concepts, and the like. Another important role of the facilitator is to make sure that students are projecting their voices so that everyone can hear.

Technology educators utilize best practices to help mold students into active and engaged learners who are skilled at critical thinking and problem solving and capable of transferring classroom concepts and knowledge to other experiences. Students who are skilled at transferring skills to new experiences are more likely to embrace lifelong learning.

Procedures in the Classroom

Technology educators employ best practices in the classroom to vary instructional methods, motivate students, promote active and collaborative learning, connect learning experiences, evoke higher-order thinking and problem-solving skills, assess student learning, and set expectations for learning, just to name a few. Examples for implementing best practices are provided below.

1. Utilize a variety of instructional delivery methods, not just lecture. Educators who tell students all of the information that they should know are limiting students' ability to predict, analyze, synthesize, and evaluate ideas and concepts.
2. Make connections between prior and subsequent learning by asking students or administering a pretest to determine what they "know" and tying it into what they will learn, through discussion.
3. Promote higher-order thinking and problem-solving skills.
4. Assessing student learning before, during, and after the lesson benefits students and teachers alike. Assessments can be quick and simple or comprehensive, depending on the situation.
5. Clear expectations for course requirements as well as quality/completion of work/assignments should be communicated to all students on the first day of class and reinforced with each assignment. Let students know exactly what you expect. For example, educators may require that students use complete sentences when responding to prompts, and that spelling and grammar errors will result in a points deduction. If this applies to your situation, make certain that students know to expect it. Essentially, educators should clearly convey to students exactly what is expected for each assignment.



6. Differentiating instruction is essential for all students to be successful.
7. Integrating curricula is essentially the same as "layering" or simply not teaching in isolation. Technology educators know that the disciplines are interwoven, rather than isolated. For example, a pulley system is definitely technology; however, it is important to understand why pulleys can make work easier by using mechanical advantage (science). Furthermore, you need to understand what type of pulley system design is needed to accomplish the desired task (engineering) and how much effort/force will be required to lift/move the load (mathematics).
8. Active learning helps establish content-based personal learning goals.
9. Classroom management: on the first day establish with your students and post clear and concise rules/procedures for instructional expectations, safety, materials/equipment, and conduct. Research suggests that students are more likely to follow rules and procedures when they understand why they are in place and are able to offer input.
10. Learner satisfaction is extremely important to students and educators. Students should feel satisfied that they are actually learning the concepts and getting as much from the course as possible.
11. Create collaborative learning opportunities for students on a regular basis. Doing so will: ensure that students are exposed to this necessary 21st Century Skill; permit more in-depth projects that require more time; and give students more opportunities to apply and enhance classroom learning.
12. One of the best ways to enhance students' transferability skills and create sustainable learning is to ensure that they are actively engaged in their own learning process.

Determine Success

You will know that you are successfully implementing best practices in your classroom when:

1. Classroom instruction is varied and interesting.
2. You are able to connect students' prior and subsequent knowledge.
3. Students can analyze, synthesize, evaluate, and apply concepts. Students are able to make predictions, solve problems, and think critically.

4. Assessment occurs before, during, and after learning takes place.
5. Students understand what is expected.
6. All levels of learners achieve success because instruction is differentiated according to content, process, and product.
7. You have purposefully integrated multiple relevant curricula into learning activities.
8. Students are actively engaged in their own learning process.
9. Your classroom is structured with clear rules, consequences, and expectations.
10. Students find relevance between course concepts and real-world applications, and topics tie in with their interests (when applicable).
11. Students are skillful and successful collaborators.
12. Students are actively engaged in their learning process and are excited and curious about learning.

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Sample of guided notes that students complete during lecture or while reading, and submit for a grade.

Introduction: The purpose of this unit to introduce students to basic 3D modeling.

A. Viewing objects and/or scenes
   1. Depending upon the ______________, the image on the monitor could be a perspective view, an orthographic view, or a combination.
      a. 3D Studio Max, Rhinoceros, and some other modeling programs open with a four-window display showing top, front, side, and perspective ___________
      b. TrueSpace opens with a single perspective view with orthographic views available on ___________
      c. Most programs allow you to fill your ________________ with any single viewport or varying multiple combinations of display windows.
      d. Various _______________ may be formed by viewing angles.
         1. The image viewed depends upon the line of sight of the __________
         2. To move across a scene is called _____________
         3. The scene may be_____________ about any of its three axes, x, y, and z.
         4. Views may be ___________ which magnifies the image. The size of the object is not increased.
      e. ________________ mimics the way a human eye works and provides scenes that have a "natural" appearance. Perspective windows are included in all 3D modeling programs.
         1. In perspective, parallel lines ___________ at a vanishing point on the horizon. Perspective views typically contain one, two, or three _________ points. Horizons may be raised or lowered to change the vertical viewing angle.
         2. In perspective, objects seem to become __________ as they move away and larger as they come closer.
         3. Objects seem to become _____________ as they move away. Atmospheric features in the software can be used to simulate atmospheric density.
         4. Perspective viewports can _____________ and "fool the eye" when trying to position objects in 3D. It is *not* a good idea to attempt object placement and alignment using the perspective window alone.

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Comparison of high-technology active learning and low-technology active learning classrooms

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Abstract
Many academic institutions are investing thousands of dollars in technology-based classrooms to market themselves as modern and adapt to the new generation of students for whom technology forms part of their everyday lives. This technology is also believed to provide the added benefit of better knowledge acquisition, improved critical thinking and greater engagement with the material. However, not many studies have examined their effectiveness in comparison with active learning classes that do not employ a lot of technology. An evaluation of a high-technology-based active learning classroom environment and a low-technology-based active learning classroom for the same organizational behaviour and leadership course is presented in this article. Results revealed no significant differences for grades between the two. However, several problems emerged with the high-technology active learning classroom. Examination of the instructors' experiences suggests that a variety of obstacles need to be dealt with if this type of classroom is to be adequately utilized and assessed.

Keywords
active learning, high-technology classroom, low-technology classroom, technology-based classroom

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Active learning

Active learning is a broad-based term that comprises different instructional methods meant to engage students in their learning and help to improve and retain higher level learning (Zepke, 2013). These methods include problem-based learning (e.g. Yaqinuddin, 2013), inquiry-based instruction (e.g. Aditomo et al., 2013; Richmond et al., 2015), self-regulated learning (Stefanou et al., 2013), experiential exercises such as focused interactive learning that encourages answering questions then engaging in systematic discussions (Harton et al., 2002), blended learning (López-Pérez et al., 2011), individual response technology (e.g. Bachman and Bachman, 2011; Powell et al., 2011), group work involving problem-solving and group work with a computer (Park and Choi, 2014). Active learning requires moving away from teacher-centred instruction where the teacher controls what gets taught, when it gets taught and the pace by which it gets taught to a student-centred approach. Student-centred instruction holds students accountable for their own learning, pacing learning to their own rhythm and learning with peers (team-based) (Prosser and Trigwell, 2014; Taylor et al., 2012). Rapid changes in technology, in addition to the vast amount of information openly available and needed to succeed in one's field, require individuals to become better consumers of knowledge and more proficient in their learning. These are some of the reasons why active learning has become an area of great interest. Constructivism suggests that 'learners are active sense makers who seek to build coherent and organized knowledge' (Mayer, 2004: 14). Therefore, instructors should guide rather than lecture (Gilboy et al., 2015). Social constructivist theory proposes that learning is a social phenomenon that requires discussing with, sharing with and teaching to others (Powell and Kalina, 2009; Shieh, 2012). Problem-solving in groups is considered ideal as students rely on their collective memory and understanding as they discuss and express ideas. Thus, knowledge is constructed as students learn from individual and shared experiences (Driscoll, 2000). Active learning, one form of student engagement, is an active, collaborative, cooperative and problem-based teaching method that gets students involved in their own learning by participating in relevant activities and thinking about the outcomes of those activities (Zepke, 2013). While the teacher-centred instruction approach is useful for transferring factual information, this student-centred approach is believed to be important for developing reasoning, problem-solving and the application of concepts to new situations (Palinscar, 1998).

Research examining the effectiveness of active learning has compared different modalities of active learning and studied different outcomes (e.g. attitudes, performance). Several studies have found that active learning promotes higher level learning (Richmond et al., 2015, 2011), critical thinking (Muehlenkamp et al., 2015), practical clinical assessments (Albanese and Mitchell, 1993), improved grade averages (Freeman et al., 2014) and enjoyment of or engagement in the classes and/or activities (Albanese and Mitchell, 1993; Muehlenkamp et al., 2015), but may not improve knowledge acquisition or lower level thinking (Richmond et al., 2011; Yaquinnuddin, 2013). Freeman et al. (2014) conducted a meta-analysis comparing active learning classes and traditional classes on performance and failure rates and found that students in active learning classes had superior grades and lower failure rates than students in traditional classes. Although this meta-analysis addresses active learning in general, it does not parcel out the role played by educational technologies. Active learning can occur with or without technology. This begs the question, 'To what extent does technology improve the active learning experience on students' perceptions and overall grades?'

High-technology active learning classrooms

Siemens (2005) suggests that changes in the work environment will necessitate changes in how people learn and the amount of information they need to learn. Examples include individuals changing jobs that require learning new fields, the encouragement of informal learning through personal networks and learning being a lifetime practice. These necessitate the use of technological advances. Moreover, some consider the integration of technology in the classroom essential given the reliance on and high consumption of technology outside of the classroom by most students (Brandtzaeg and Heim, 2011; Isaías et al., 2015; Lichy, 2012; Mott, 2010; Mutekwe, 2015; Taylor and Keeter, 2010). This has inspired instructors to employ social media such as twitter (e.g. Prestridge, 2014) or student-generated audio files (e.g. Bollinger and Armier, 2013) in the classroom. At the institutional level, more colleges and universities are designing and building classrooms that facilitate small group work and integrate computers at most student work stations (i.e. high-technology active learning classrooms) with the hope that they are better than low-technology active learning classrooms whereby the classroom set-up follows the traditional model of desks and chairs but with the instructor employing active learning methods. The trend in many physics, engineering, math and some literature programmes has been to remodel many of their large classes in this manner (Park and Choi, 2014). There are presently over 250 institutions in the United States, and many outside the United States, that have designed SCALE-UP classes (Student-Centered Active Learning Environment with Upside-down Pedagogies; Beichner and Saul, 2003) that are meant to encourage collaboration, and interactive experiences in a computer-rich environment (Beichner et al., 2007; Foote et al., 2014; Knaub et al., 2016; Park and Choi, 2014). Because more and more instructors and institutions are embracing active learning (Park and Choi, 2014) and because of technology's importance to the individual (Mutekwe, 2015; Siemens, 2005), incorporating technology in the classroom has the potential to be viewed favourably and assist in learning.

Research examining high-technology active learning class environments found students express a more positive view of learning in these classes than in traditional teacher-based classrooms (Park and Choi, 2014). Others have found that redesigning classrooms results initially in favourable attitudes that soon wane (e.g. Perks et al., 2016). Shieh (2012), using a high school sample, found students in a technology-enabled active learning classroom outperformed students from a traditional classroom on one out of two tests of knowledge. She also found students enjoyed the class more. DeBord et al. (2004) compared computer-assisted teaching interventions added to an introductory psychology class versus a traditional approach, and although they found no grade differences, students preferred the computer-assisted class. Other research found no benefits (De Witte and Rogge, 2014) or potential problems with the high-technology active learning environment, such as students becoming disengaged and getting distracted by communicating with peers on irrelevant topics (White et al., 2014).

Although there is a trend to increase technology in the classroom (e.g. Elliot and Neal, 2016; Heilesen, 2010; Lunt and Curran, 2010), there are aspects of this new pedagogical tool that could lead to less than satisfactory outcomes. How the academic environment is structured influences what and how students learn (Choi et al., 2014; Stefanou et al., 2013). It is the case that the environment not only advertises subconsciously how people should learn but also how information should be transmitted, how engaged individuals should be with the material and who holds the power. These are multidimensional dynamics that are not always under the control of the instructor. When a class has students who do not wish to engage with the material, but must interact with other members of their group, their lack of interest in the material might get transmitted to other students and change the social dynamics of the classroom. The instructor's power or role is changed in a class environment where students are responsible for their own learning and computer screens and keyboards may act as physical barriers, thus making it difficult to re-engage students.

White et al. (2014) suggested that students may not be developmentally ready to engage in this manner. Research has shown that certain personality and learning styles are correlated with academic achievement (e.g. Baeten et al., 2010; Bliuc et al., 2011; Furnham, 2012; Komarraju et al., 2011; Li et al., 2014; Von Stumm and Furnham, 2012). One possibility may be that individuals with certain personality types or learning styles may prefer the high-technology learning environment (Ellis, 2016). The strictly traditional classroom that does not require overt student participation/involvement has often been criticized as students' attention and motivation may wane (Cavanagh, 2011). However, the technology-based environment may result in requiring some students to engage with material when they are not mentally prepared to, as some may work and think better when alone rather than in groups. Different students with different knowledge and learning styles may engage with the material at a different pace; therefore, working in teams may not be conducive to a positive learning environment for those students. Certainly, problems with group dynamics emerge when individuals work in teams (e.g. Forsyth, 2014). For instance, Eddy et al. (2015) found that roles in peer discussions in an active learning classroom depended upon the gender, ethnicity and nationality of the student as well as three potential barriers to effective group communication such as being excluded by others, feelings of anxiety about participating and not appreciating the importance of group discussions.

In summary, there is a trend to create high-technology-based classrooms with the underlying belief that they are better suited to encourage active learning; however, in our literature review, we did not find published studies comparing high-technology-based versus low-technology-based active learning classrooms (i.e. active learning classrooms were compared with traditional classrooms, for example, Cotner et al., 2013). There is extensive support that active learning is beneficial in many respects, but to what extent does technology need to be integrated in the classroom in order to improve student performance? Jensen et al. (2015) compared a flipped classroom (content is shifted to online material that students are expected to learn on their own and in-class time with the instructor is spent on activities meant to apply and consolidate what was learned online) and a comparable class that employed active learning but was not flipped. They found no differences between the two classes and suggested that active learning itself is the key component to a successful course. Therefore, there is a need to find out whether a classroom physically designed to encourage small group work and the use of computers results in better acquisition of material than a classroom that is similar in all respects (i.e. course content and goal of employing active learning) except for the computers, desks and chairs set-up. Furthermore, it would be interesting to determine whether students in different programmes of study benefit more or less from this type of classroom as there is also a trend to employ these types of classrooms in certain disciplines. The goal of the programme evaluation presented here was to compare the effectiveness of two different modes of teacher-student engagement.

Method

Participants and procedure

The courses were held at the Royal Military College of Canada (RMCC) from September to December, 2015. This is a Canadian military academic institution for Naval Cadets and Officer Cadets who are completing a 4-year undergraduate degree while undergoing military and physical training and working towards proficiency in Canada's two official languages. The majority of participants were male (there is roughly an 80:20 ratio of males to females at the college), in their third year of a 4-year degree, and around 19–20 years of age.

Both instructors who participated in the study had several years of experience teaching in a low-technology active learning classroom using PowerPoint as well as student and group participation activities in the class. Both taught different sections of the same Organizational Behaviour and Leadership course (a mandatory course for all students across all degrees), and covered the same content. Sections are taught in English and in French with identical textbooks used across the same-language sections. Different, but comparable, textbooks were used in the two languages. A common set of PowerPoint slides is utilized by the instructors.

There were two low-technology active learning classes, one taught in English with 18 students from the Arts Division and the other taught in French with 19 students from the Science/Engineering Divisions. There were two high-technology active learning classes, one offered in English with 21 students from the Science and Engineering Divisions, and the other offered in French with 16 students from the Arts Division. All English classes were taught by the same instructor and all French classes were taught by the same instructor. Students were assigned randomly to each of the classrooms based on their programme and schedule. The students were not verbally told that they had the option to leave the class to which they were assigned. Nonetheless, the instructors were open to the possibility of accommodating student requests. In the end, no student requested a change of class.

Low-technology active learning classroom. The low-technology active learning class took place in a conventional teaching environment with student desks and chairs and a black board. A projector was available for the professor in order to use software (predominantly Microsoft PowerPoint) to deliver the material. The 3 hours of material were generally divided into 2 hours of lecture format and the last hour for application exercises in class. The 2 hours of lecture normally comprised an interactive teaching style. For instance, videos or short clips were sometimes used to reinforce the content proposed to the students, in addition to individual reflection and class discussions on the weekly topic covered. The 1-hour period generally involved the use of group exercises encouraging the participation of all students in the weekly content. Some of the exercises were hands-on projects (e.g. the Marshmallow exercise (Wujec, 2010) covering the topic of team work, the Alligator river exercise (Humber, 2016) covering the topic on values, and the Village of 100 participants activity (Goldstein, 2008) covering the topic of diversity); others involved group discussions or student-directed teaching using the Jigsaw method, a research-based cooperative learning technique developed by Elliot Aronson in the early 1970s (Aronson and Patnoe, 2011).

High-technology active learning classroom. The high-technology active learning class took place in a refurbished classroom. The environment comprised an open space, 25 mobile chair-and-desk sets, five wall-mounted flat screen and computer stations, and a podium with a master computer for the instructor. All students determined at which station they would sit and were given a quick orientation starting with a definition of the active learning concept and a demonstration of the technology and the available options. This setting allowed a more collaborative environment for the students and was designed to encourage student engagement. Students were initially given some time to play with the equipment in order to gain familiarity. Through the podium and master computer, the instructor had central access to all the computers when needed. With this classroom, Microsoft programs, Smartboard capabilities and ready Internet access were available to the students. The 3 hours were divided generally the same way as the low-technology classroom. Originally, different exercises were built around the specific technology available to those students (e.g. i-clickers); however, with time, the contents in both classes were comparable except that the technology used to perform them was different.

Measures

Final grades of students were used to compare knowledge acquisition. Furthermore, the institution's teaching evaluation form was used to learn about students' opinions of their experiences. This is a standardized form used across all courses and asks 12 questions. For the purposes of this evaluation, we compared classes on whether the delivery of the course by the instructor was organized, whether the instructor provided a supportive learning environment whereby students felt comfortable talking and asking questions, whether this was overall a good course and whether students participated. Open-ended questions are also part of the course evaluation, and were thus included here. Completion of the course evaluation was voluntary. Finally, the instructors' observations throughout the semester were also recorded.

Results

Preliminary analysis for grades

There were no failures in any of the classes. The range of grades for the low-technology active learning class Arts students taught in English was 51–87 ($M=72.7$, standard deviation (SD)$=10.6$), 51–86 for the low-technology active learning class Science/Engineering students taught in French ($M=70.9$, $SD=8.4$), 53–92 for the high-technology active learning classroom Arts students taught in French ($M=69.8$, $SD=10.3$) and 57–90 for the high-technology active learning course Science/ Engineering students taught in English ($M=78.0$, $SD=9.1$).

Analysis for grades

Assumptions of normality were held and there were no concerns over outliers. We did not have enough participants to run a $2\times2\times2$ analysis of variance (ANOVA) (i.e. division × instructor × group). Our primary interest was to examine grade differences between the high-technology active learning classes and the low-technology active learning classes, but because these classes had students from different divisions and were taught in different languages (by two separate instructors), we wished to control for these differences. Therefore, we conducted three separate 2×2 ANOVAs (e.g. division × instructor, division × classroom, instructor × classroom).

For the division × instructor analysis (and the instructor × classroom analysis), there was a significant difference for grades between the two instructors ($F(1, 70)=5.0$, $p=0.028$, partial eta squared $=0.07$). Unfortunately, this was confounded by language (i.e. we do not know whether the difference is due to instructor or language, in this case language differences also include cultural differences between Anglophones and Francophones). There were no other significant effects for either the division × instructor or instructor × classroom analyses.

There was a significant interaction effect for division and classroom ($F(1, 70)=5.0$, $p=0.028$, partial eta squared $=0.07$); the Science/Engineering students in the high-technology active learning classroom had higher grades than all of the other groups. No significant main effects for the high-technology active learning classrooms versus low-technology active learning classrooms were found, but this is qualified by the previously noted significant interaction effect.

Analysis for student evaluation questions

A range of 5–11 students per class completed the voluntary course evaluations. This limited participation did not permit any meaningful statistical comparisons into the four critical questions focusing on the students' opinions with respect to certain delivery components of the course.

Students' experiences with the high- and low-technology active learning classrooms

Overall, students appeared to express positive attitudes about both the high-technology and the low-technology active learning classrooms. Comments regarding the low-technology active learning classes included the following: 'Loved the flexibility of the weekly assignments, and how they encouraged me to read ahead', 'Lots of group case studies to apply larger concepts in class … very helpful', 'The course was well prepared and structured. The theory was well explained and the learning curve was progressive' and 'Very good course'.

Comments regarding the high-technology active learning classes included the following: 'This experimental structure of the course was very interesting and made coming to class a lot of fun', 'The format of the lectures kept me really involved', 'Please keep and extend this experimental format with the multiple screens and presentations', 'The new learning environment was interesting overall and I found it most useful for learning new topics through the PowerPoint activities' and 'I was feeling distracted by the multimedia environment. Coming from an engeenering [sic] background, I think it is better to have a normal course'.

Teaching experience with the high- and low-technology active learning classrooms

Throughout the term, weekly meetings were held between the authors of this article to learn from the instructors about their experiences with the high- and low-technology active learning classrooms (the two instructors were also authors of this article). The instructors noted a few negative consequences of incorporating the technology in the classroom. These were organized under four subheadings: student participation, technology or physical space problems, difficulty with the technology and social processes.

Students' participation. The course taught is mandatory for all students completing a degree at RMCC. Therefore, a few students resented being forced to take the compulsory course, and as a result, they displayed minimal effort towards the active learning process and at times disengaged from the task at hand. These students did not appear excited by the experience of participating in class in this manner and brought their negative attitudes into the classroom. This active disengagement was worse in the high-technology active learning classrooms because they would actively disturb the group or redirect their attention to something else (e.g. YouTube videos). Students would present irrelevant material to the class on the board from their computer. These disruptive students presented an additional challenge for instructors, diverting attention away from delivering the course material. On the other hand, the low-technology active learning classroom students who disengaged would be quiet, and secretly attempt to go on their cell phone to play games, thus disturbing their peers and instructor less. (Disruptive behaviours from military cadets may seem surprising given that the military holds high standards of obedience and discipline. These behaviours can be partly explained by the young age of the cadets (most come to RMCC immediately from high school) which may result in immature behaviours (given the small size of the College) along with focused attention on starting their careers as officers rather than their education).

Technology or physical space problems. Technological issues or classroom space problems prevented the smooth running of the high-technology active learning classroom. Sometimes the central computer station did not properly work and the instructor had to rely on the students' computers to transmit the information. Sometimes two out of five monitors would not work, thus requiring students to re-organize their groups or go low-tech. Students could hear the other groups working on the solutions (or being engaged in non-class material) and would either try to appropriate the other groups' ideas or be distracted. The instructors found that the computer monitors acted as a physical barrier to the necessary visual contact with the students and had to frequently move around the classroom to compensate for this issue. Despite being subjected to closer scrutiny, students would often continue to keep their eyes fixed on the monitor.

Difficulty with the technology. Some students appeared to have difficulty learning in this manner. They had difficulty with the technology, and either required more structure for the in-class activity, or needed regular reminders of how to operate the equipment that often precluded them from completing the required task.

Social processes. Social processes also played a role within the learning environment. One student who was known to be a good student was in a group with students known to lack motivation towards their schoolwork. Over the course of the term, it was observed that the good student's participation decreased, and the student began demonstrating disengagement behaviours (e.g. cell phone use). Other students appeared stymied in their ability to discuss ideas. They seemed to have difficulty processing information in front of others and in a short timeframe.

Discussion and conclusion

Although numerous high-technology classrooms are being built in many educational institutions (e.g. Beichner and Saul, 2003; Loughlin et al., 2015; Park and Choi, 2014), we do not know whether students achieve higher grades in those types of environments than in low-technology classroom environments that employ active learning techniques. We explored differences in performance and student and faculty perceptions between two high-technology active learning classrooms and two low-technology active learning classrooms. We found no overall significant differences between the two types of classrooms on grades. However, there was a significant interaction effect such that the Science/Engineering class in the high-technology-based active learning classroom had higher grades than any of the other classes. Qualitative results from a few of the students were favourable across both classroom types. However, the instructors noted various problems with equipment, student non-participation, difficulty with using the technology and some problematic group dynamics preventing the emergence of the high-technology classroom's full potential.

Active learning involves students being responsible for their own learning, determining the pace of that learning and learning with others (Zepke and Leach, 2010). However, the instructors found that the high-technology active learning classroom did not always create an environment that was conducive to engaging in this self-paced, responsible learning. Rogers et al. (2015) found that it took numerous years, a certain level of instructor experience and changes to the curriculum before benefits would be incurred. Other researchers found similar problems for faculty implementing different types of technology in their classrooms (e.g. Veletsianos et al., 2013). As Ertmer and Ottenbreit-Leftwich (2013) suggest, it may be more important to have a pedagogy-driven approach to integrating technology in the classroom rather than a technology-driven approach. Ge et al. (2015) found that instructors' attitudes towards the use of technology played an important role in the extent to which it gets employed in the classroom. Instructors may be discouraged by the amount of self-education required and changes in teaching style while institutions may unrealistically expect immediate returns. Our research certainly suggests that problems with equipment and lack of extensive instructor experience in this type of classroom may explain the lack of significant improvement in grades in this environment.

Technology itself may play a role in fostering a student's motivation to engage in the material, but it may also hinder it depending upon individual differences. White et al. (2014) experienced problems regarding student disengagement; students frequently used group work exercises as an opportunity to talk with friends. The activity/exercise/laboratory employed interacts with the technology meant to showcase the important pedagogical features of the learning activity, but their functionality and success depend upon a student's willingness to engage with the material, their willingness to engage in this manner, as well as their personality and learning style (e.g. Baeten, 2010; Bluic et al., 2010; Furnham, 2012; Komarraju et al., 2011; Li et al., 2014; Moss et al., 2010; Von Stumm and Furnham, 2012; Walls et al., 2010). Certainly, when active learning involves students interacting with their peers, numerous group processes and dynamics such as social loafing; differences in power, cohesion and structure (Forsyth, 2014); as well as individual differences (e.g. Eddy et al., 2015) can intervene and result in poorer learning outcomes. Technological renovations to a classroom by themselves cannot overcome the difficulties that stem from performance losses due to interpersonal processes.

There were several limitations to this research. One was that only one course was considered and the samples in the different conditions were from a military college where class sizes are small and most students are male. Although this made the groups comparable as the class sizes and course content were similar across conditions, the extent to which our findings would generalize to larger classes, other universities and other subjects, for instance, would have to be studied. Finally, many university instructors/professors enter in their academic careers with little to no actual instruction on how to teach and little to no active feedback designed to improve their teaching style. Most have learned to teach by modelling others and these others were, for many, in a traditional instructor-lecture student-receiver environment. Instructors have not necessarily learned how to coach or act as facilitators, particularly in a technology-based classroom, thus some of the techniques required by instructors to engage students in a technology-based active learning environment have to be learned on the spot. Our instructors were new to the high-technology classroom; although this made the conditions comparable, perhaps results would be different for instructors who have taught in this environment for a few years. Certainly, Rogers et al.'s (2015) work suggests this.

Many institutions are embarking on creating these types of new learning spaces, but there is little research examining which elements are important for maximizing their utility. More research needs to be conducted for different subject matters being taught, class sizes and level of instructor experience. For example, it is possible that class size acts as a moderator; in small classes, no differences emerge, but differences may be found for larger classes. Given that some research has demonstrated that active learning has an influence on higher level learning or practical experiences, but possibly not lower level learning (e.g. Richmond et al., 2011; Yaqinuddin, 2013), it would be interesting to examine these differences, which an overall grade cannot assess. We note that the novelty of such a classroom can have an interesting impact on student attitudes and possibly student learning as found by Perks et al. (2016). Once the novelty has worn-off and more students are exposed to this type of classroom, to what extent will attitudinal benefits be found? Differences between students who were exposed to many courses taught in a high-technology classroom versus students who were not exposed and those who were minimally exposed should be examined. The expectation of engaging in technology and individual differences in preferences to engage with technology in the classroom could also change over time as more and more young people gain lots of experience with technology both outside and in the classroom.

Our results suggest no grade differences between high-technology and low-technology active learning classrooms. Group process losses as well as lack of instructor experience in a high-technology classroom environment may explain these results. We believe active learning is important for application of knowledge, critiquing it and analysing it; but classrooms that provide a lot of visual and intellectual distractions may not be a better means by which to engage students. This may be particularly the case for small classes and when the course content does not require the use of sophisticated software to illustrate key concepts or theories or to gain experience with the material. Lumpkin et al. (2015) suggest that traditional teaching encourages students to be passive. To what extent will high-technology active learning classrooms encourage social loafing, and is this environment best suited for those students who enjoy and have a learning style that requires being actively engaged for 1–2 hours? Requiring students to be actively engaged most of the time, without any opportunity to tune-out and engage passively with the material, may be problematic. We suspect that this type of classroom may encourage deeper processing and understanding if the programmes employed were designed and developed to meet specific learning objectives that require technology, such as working in a virtual world, visualization software and simulations (Driscoll, 2002).

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DEVELOPMENT ARTICLE

From swimming pool to collaborative learning studio: Pedagogy, space, and technology in a large active learning classroom

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Abstract To promote student learning and bolster student success, higher education institutions are increasingly creating large active learning classrooms to replace traditional lecture halls. Although there have been many efforts to examine the effects of those classrooms on learning outcomes, there is paucity of research that can inform the design and implementation process. This study investigates how spatial and technological features of a large collaborative classroom support active learning based on the Pedagogy-Space-Technology framework. The findings from our study suggest short lecture and class-wide discussion are essential in framing learning content before group activities, and connecting group outputs to the learning content after group activities. Through interviews, surveys, and focus groups, we found that-while small group activities are generally well-supported in large active learning classroomsfacilitating short lecture and class-wide discussion is key to the success of active learning in large classrooms. Technology should be carefully laid out in the space to accommodate those activities. Specific design and implementation suggestions and implications are provided.

Keywords Active learning classroom · Active learning space · Active learning · Collaborative learning · Technology integration · PST framework · Student-centered learning · Instructional technology

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Creating a large active learning space involves efforts from people with different expertise including classroom designers, architects, technology specialists, and instructional consultants who are focused on a question: how can intentional space design and technology enable a physical learning space to facilitate what was difficult or impossible in a traditional lecture hall? Lecture halls have worked for the teacher-centric, lecture-intensive instructional model. However, it is clear from the learning literature that students in passive lecture settings often do not learn as much as hoped, and a growing body of research on active learning strongly and consistently supports this claim (e.g., Beichner 2014; Freeman et al. 2014).

Early initiatives such as North Carolina State University's SCALE-UP, Massachusetts Institute of Technology's (MIT's) TEAL, and the University of Minnesota's PAIR-UP have consistently shown positive student outcomes in comparative studies (Beichner et al. 2007; Brooks 2012; Dori and Belcher 2005). Encouraged by positive outcomes, an increasing number of higher education institutions have adopted a large active learning classroom model (Beichner and Cevetello 2013). This trend of redesigning learning spaces to better support active learning approaches is predicted to continue, according the 2015 NMC Horizon Report (Johnson et al. 2015).

In response to similar curricular and instructional needs at a Midwestern university, a large, technology-enhanced active learning space has been built as an alternative to a traditional lecture hall. This space was originally a swimming pool and then later a map library, before being renovated as a large active learning space, called Collaborative Learning Studio (CLS, see Fig. 1).

This study investigates the instructional components and classroom activities that support active learning, and how spatial and technological features of the CLS reflect design and implementation processes based on the Pedagogy-Space-Technology framework (Radcliffe 2008).

The PST framework

The pedagogy-space-technology (PST) framework has been developed for the design and evaluation of active learning spaces in order to help stakeholders critically and holistically consider the three aspects and their interactions (Radcliffe 2008). The PST framework provides an inquiry-driven process to ensure stakeholders take a balanced approach grounded in pedagogy by asking questions related to types of learning and teaching in the space; space design, furnishings, and effective utilization of the space; and technology

Fig. 1 Swimming pool (left) to collaborative learning classroom (right)

integration and its effectiveness. The three components are interrelated, as illustrated in Fig. 2. Technology extends space and enhances pedagogy. Space that embeds technology encourages certain pedagogy. Pedagogy is enabled by space and enlarged by technology.

Active learning spaces are intended to support collaborative, active, learner-centered pedagogical approaches that are theoretically based on social constructivism–theories that emphasize meaningful social interaction as key to knowledge construction (Dillenbourg 1999; Littleton and Häkkinen 1999; Palincsar 1998). Related learning approaches include cooperative learning (Johnson and Johnson 2009), team-based learning (Michaelsen et al. 2002), collaborative problem-based learning (Barrows and Tamblyn 1980; Hmelo-Silver 2004; Savery 2006), and collaborative project-based learning (Bell 2010; Blumenfeld et al. 1991). The term active learning, as used in this article, refers to the wide range of instructional approaches that actively engage learners in the learning process rather than having them passively receive information from their instructors (Prince 2004). In active learning, student collaboration, cooperation, or discussion at the very minimum plays a central role in the learning process–which is why the term collaborative learning is often used to refer to active learning approaches (Prince 2004).

From the perspective of classroom design, collaborative learning involves two types of classroom activities: (1) small group or within group discussion, and (2) class-wide, cross-groups discussion. That is, instructors not only engage students in small group discussion but also ask students to share what they have learned with the entire class, provide feedback and encourage other students to give feedback, or compare and contrast different groups' processes and outcomes. For this reason, design decisions regarding space configuration and technology selection should be based on effectively and efficiently supporting these activities. Therefore, we examine to what extent space configuration and hardware technologies in four widely known enlarged active learning classroom models facilitate these two classroom activities.

Active learning classroom models

In this section, we briefly review four widely known and actively researched active learning classroom models that replaced traditional lecture halls: North Carolina State University's SCALE-UP, MIT's TEAL, the University of Minnesota's PAIR-UP, and the University of Iowa's TILE.

Although active learning has been around for a long time, the development of active learning spaces in higher education has generally moved from science, technology, engineering, and math (STEM) courses to multiple disciplines, and from very structured course redesigns to broadly supporting multiple disciplines and instructional approaches. The

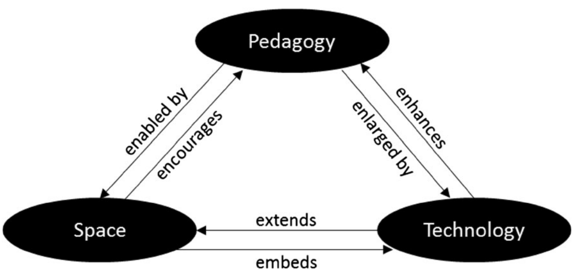

Fig. 2 The PST framework (adopted from Radcliffe 2008, p.13)

most widely-adopted and well-known active classroom model in higher education is SCALE-UP (Student-centered active learning environment with upside-down pedagogies), developed at North Carolina State University in the mid-1990s (Beichner 2014), which was originally focused on physics instruction and later expanded to other disciplines. Adopted by more than 150 institutions worldwide, the model reflects a flipped classroom pedagogy where students engage with the learning material and take quizzes before coming to class, and perform hands-on collaborative learning activities in class (Beichner 2014; Beichner et al. 2007). SCALE-UP helps instructors integrate experiments into courses in a studio-type physical learning space, where students can carry out labs in small groups while being coached (Beichner et al. 2007).

In an effort to improve attendance and failure rates in first year physics classes at MIT, the TEAL (Technology-Enhanced Active Learning) project team adopted the SCALE-UP model for large introductory courses. TEAL combines mini lectures, simulations, and hands-on desktop experiments in a collaborative learning format (MIT iCampus, n.d.). For desktop experiments, data is linked to student laptops where it can be visualized and simulated (Dori et al. 2003).

Based on the SCALE-UP and TEAL models, the University of Minnesota's PAIR-UP (Pedagogy-rich; Assess learning impact; Integrate innovations; Revisit emerging technologies) model takes an interdisciplinary approach to designing flexible classrooms that facilitate collaborative student-centered learning approaches (Whiteside et al. 2009). The PAIR-UP initiative's active learning classrooms are designed with the expectation of students bringing and using their own computing devices (Whiteside et al. 2009).

Built on the SCALE-UP model, the University of Iowa's TILE (transform, interact, learn, engage) initiative is an effort to transform teaching practices through faculty engagement in pedagogical changes to inquiry-guided learning, peer instruction, and in-class, team-based learning (Florman 2014; TILE: Transform, n.d.). The initiative takes a unique approach to expansion, providing pedagogical training for faculty members who will be developing new TILE courses and teaching them in the TILE classrooms (Florman 2014; Van Horne et al. 2012). Table 1 summarizes spatial and technological features of the major collaborative learning classrooms.

Previous research and knowledge gaps

The majority of the research that has been conducted has focused on student learning outcomes, engagement and perceptions of the learning spaces, and classroom activities. Consistently, students taught in active learning spaces have outperformed peers taught in traditional lecture-hall settings and showed positive attitudes and engagement according to student performance data (Baepler et al. 2014; Beichner et al. 2007; Brooks 2011; Dori and Belcher 2005; Van Horne et al 2012; Walker et al. 2011; Whiteside et al. 2010).

Nevertheless, there is paucity of systematic research that informs design and development of large active learning classrooms. More specifically, there is limited research on how and how well spatial and technological features of those spaces support various classroom activities. Previous research indicates that, although those spaces were designed to facilitate small group activities, lecture and class-wide discussion were regularly performed. However, some incompatibility issues with these two activities were reported (Brooks 2012, Van Horne et al. 2014; Walker et al. 2011). In this study, our research questions are: (1) what types of instructional components or class activities support active

Table 1 Spatial and technological features of large collaborative learning classrooms

Learning model	Classroom activity	Space	Technology
SCALE-UP	Small group discussion	Seven-foot round tables that seat nine students	Three laptops per table Ceiling-mounted projectors Portable group white boards Wall-mounted whiteboards
	Class-wide discussion	Instructor's station at the center	Wireless microphone Celling-mounted projectors Document viewer
TEAL	Small group discussion	Thirteen round tables that seat nine students	Three laptops per Table 13 whiteboards Eight screens on the wall
	Class-wide discussion	Instructor's station at the center	Instructor's display Eight wall projectors/screens Personal response system
PAIR-UP	Small group discussion	Round tables that seat nine students	Individual laptops Wall-mounted display technologies for students
	Class-wide discussion	Instructor's station at the center	Instructor's display Wireless microphones Wall-mounted display technologies for students Signal lamp at tables
TILE	Small group discussion	Round tables that seat nine students	Three laptops per table Nine wall-mounted LED monitors Wall-mounted white boards
	Class-wide discussion	Instructor's station at the center	Instructor's desktop, display, whiteboard, and wireless mouse Nine wall-mounted LED monitors

learning (including what a typical class day looks like in the CLS), and (2) how technology and space configuration of the CLS supports each instructional component.

Methods

Context: collaborative learning studio (CLS)

This study was conducted in fall 2013, when the CLS opened. Eleven undergraduate level courses were taught by a total of 10 faculty members (one taught two courses during the fall semester). Five faculty members personally requested the room through their departments, and departments or the Registrar assigned the other five to the room. Because the CLS was created out of the needs of the departments of anthropology and geography, priority scheduling was given to them. After satisfying their requests, the Registrar filled additional open class times based on other departments' needs for technology as well as room size and characteristics.

The courses taught in the CLS were 100 through 300 levels in disciplines including anthropology, arts and sciences, geography, sociology, and public health. Most classes met twice a week for 75 min, except one class which met once a week for three hours and another class which met three times a week for 50 min. Student enrollments ranged from 26 to 86, with an average of 50. Faculty scheduled to teach in the CLS received training on the technologies from the campus teaching center. Instructors could also request one-on-one consultations about how to design a course that incorporates active learning approaches and how to better utilize room features to support those approaches.

The CLS is a large technology-enhanced active learning classroom space that was designed to facilitate active learning approaches in large classes. The CLS, takes advantage of state-of-the-art technologies to provide rich learning experiences for students in multiple disciplines. While some early active learning classroom projects were focused on supporting course redesigns in specific disciplines—namely physics for SCALE-UP and TEAL—the CLS was meant to be a space that could support a variety of active learning approaches across a variety of disciplines.

Figure 3 shows the layout of the CLS with technological features. The CLS has two levels: lower and upper classroom. There are a total of 16 student Tables (10 on the lower level and six on the upper level) with six chairs, a desktop computer, and two microphones at each table. The unique feature of this room is a 20-foot wide video wall in the front of the room in the lower classroom area, which was added to better facilitate class-wide and cross-group discussion.

The 16 panels of the video wall can simultaneously display the 16 student monitors using a gallery view. The video wall also accommodates the display of one large view or a quad view of four sources either from student monitors, desktop computers, laptop, or the document camera at the instructor's main station. Instructors can use their display control panels to select what to display, how to display (gallery view, quad view, or one large view), and where to display (the video wall, two projector screens, or student monitors). There are two control panels: one located on the lower classroom level near the instructor's

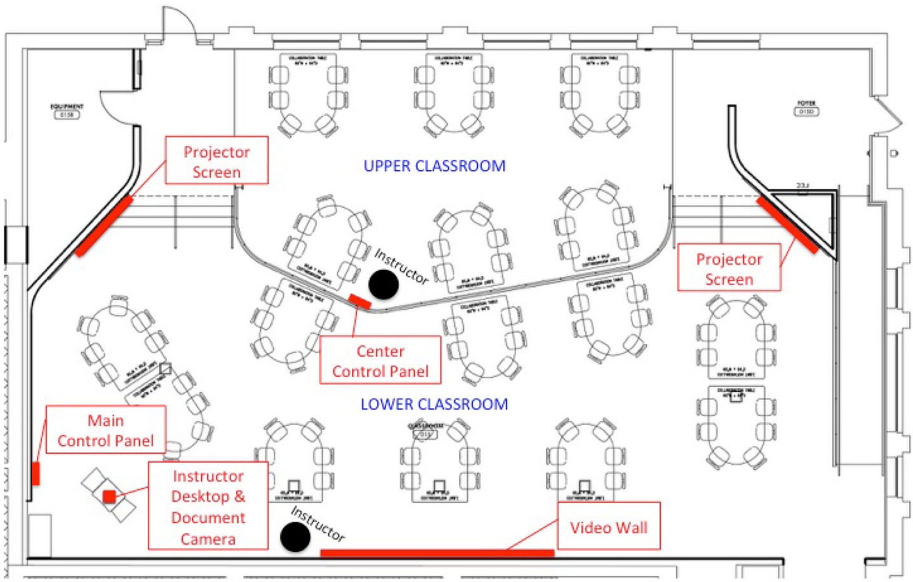

Fig. 3 Instructor's locations in the CLS

Table 2 Spatial and technological features of the CLS

Classroom activities	Space	Technology
Small group discussion	16 U-shaped tables that seat six students	Each student table contains: One desktop One LED monitor Connections for three laptops One document camera One portable whiteboard
Class-wide discussion	Instructor's stations in the front corner and the center	Video wall Two control panels Two wall-mounted projectors/ screens Speaker and two push-to-talk microphones at student tables Instructor's desktop and controls Instructor's wireless microphone

station and the other located on the upper classroom area. Table 2 summarizes spatial and technological features of the CLS.

After the first semester of operation, the following technologies were added in fall 2014 in response to faculty's feedback. At the student tables, document cameras, portable white boards, and speakers were added. Instructor's wireless microphone was provided to allow the instructor to move freely in the CLS.

Study design

In order to capture qualitative and quantitative dimensions of what was happening in the CLS, we chose to deploy and combine multiple forms of data collection in a convergent parallel mixed methods design (Creswell et al. 2007), validating findings through triangulating data from multiple sources (Johnson and Onwuegbuzie 2004). We collected data from faculty and students who used the CLS in fall 2013 regarding their teaching and learning experiences. Additionally, we conducted another survey in fall 2015 (fall 2015 survey) with faculty members who taught in the CLS in the fall and spring semesters of the following academic year. The purpose of this survey was to examine how often they used technologies that were added in fall 2014 as well as to ask additional questions about other technologies including the video wall.

Data collection

In fall 2013, we collected data through: (1) one-on-one semi-structured interviews with four faculty users of the CLS, (2) two focus group interviews with a total of 11 students, (3) online faculty survey, (4) online student survey, and (5) nine syllabi for courses taught in the CLS. Additionally, we sent another survey to faculty. Interview questions and survey items were developed to capture their uses and perceptions of the space and technology in classroom activities. Learning or student performance data was not collected given the purpose of the study. The authors and another researcher developed the questions together and went through several iterations of revision of the items. Table 3 presents data sources,

Table 3 Data sources, number of responses, and representation of the fall 2013 courses

Discipline	Level	Faculty interview	Faculty survey	Student focus group	Student survey	Syllabus
Anthropology	100	1	Anonymous[b]	1[a]	4	1
Anthropology	200				1	1
Arts and sciences	100	1				
Geography	100			1		1
Geography	200	1			3	1
Geography	200	1				1
Sociology	200					
Sociology	300					1
Public health	100			3		1
Public health	200			6*	17	1
Public health	300			1	15	1
Total	11	4	9	11	40	9

[a]A student who was enrolled in two courses taught in the CLS was counted for both courses

[b]Identifiers were not collected in the faculty survey

number of responses, and representation of the courses taught in the CLS in fall 2013. In fall 2015 survey, 10 out of 19 faculty members responded after teaching in the CLS in the academic year of 2014–2015.

Faculty interviews

Interviews with faculty aimed to capture information about teaching experience, implicit and explicit collaborative learning pedagogy, the use of the space and technology of the CLS for collaborative learning, and expectations and concerns related to use of the CLS. Faculty one-on-one interviews were semi structured. Questions include how they implement collaborative learning in the space, what were the most successful and the least enjoyable teaching experiences, how they perceive usefulness of the space and technologies, whether they have concerns or reservations about using the space, and what improvements can be made. See Appendix A for the full interview questions. Four faculty members were interviewed (3 women and 1 man).

Faculty online survey

The faculty online survey aimed to capture information about overall teaching experiences in the CLS. There were seven questions. Two were close-ended questions asking (1) whether the room was personally requested and (2) how many semesters they taught in the CLS. The remaining five questions were open-ended and asked what they do differently in the CLS, how teaching experience in the CLS affected their pedagogy, changes in student attitudes or behaviors, and what they liked and found challenging about the space. See Appendix B for the full survey items. The anonymous online survey was distributed toward the end of the semester, and nine faculty members responded out of 10.

Student focus groups

Focus groups aimed to capture overall student learning experiences in the CLS, their attitudes toward collaborative learning, and perceptions of the space and technology in relation to collaborative learning. Focus group interviews were semi structured. Questions include what a typical day is like in the CLS, how the instructor uses the space and technology, how they perceive effectiveness and value of collaborative learning, what are their likes and dislikes about the space and technology. See Appendix C for the full focus group interview questions. Faculty members were asked to distribute the invitation to their students. Eighty-four students volunteered, and 11 from five different courses were randomly selected based on their availability during the times when the CLS was open. Two focus group interviews took place with five and six students each in the CLS (9 women and 2 men).

Student online survey

The student online survey also aimed to capture information about overall learning experiences in the CLS. There were eight questions. Five closed-ended questions include frequency of technology use in the CLS (*used every class meeting, occasionally used, rarely used, and never used*), appeal of the technological and spatial features of the CLS, and helpfulness of the video wall and group activities in their learning (*a great deal*, *somewhat helpful*, and *not at all helpful*). Three open-ended questions include which activities worked best in the CLS, which activities worked least well in the CLS, and how the room helped or hindered learning. See Appendix D for the full items. The faculty members were asked to distribute the survey link to their students near the end of the semester. This survey was anonymous except for a course identifier, and 40 students from five courses responded.

Syllabi

Nine faculty members provided course syllabi for the fall semester. The syllabi provided a better understanding of course objectives, class structure and activities, course schedule, and assessment structure.

Fall 2015 faculty survey

The additional fall 2015 faculty survey aimed to capture frequency of usage of the added technologies as well as specific uses of the video wall. The survey was comprised of 12 questions. We asked how often they used added technologies such as document cameras, microphones, portable white boards, speakers, and instructor's wireless microphone. Additionally, we asked how often they used the push capability of the video wall and how frequently each view of the video wall was used in displaying lecture materials, comparing student work, monitoring student work, and displaying a combination of instructor and student materials (*used every class meeting, once every few class periods, a few times during the semester, and never used*). We also asked about their perception of video wall effectiveness for class-wide discussion and monitoring student group work (*very effective, somewhat effective, somewhat ineffective, very ineffective*) with an option of *not used for* *the purpose*. See Appendix E for the full survey items. The survey was distributed to 19 faculty members who taught in the CLS during the 2014–2015 academic year.

Data analysis

The PST framework structured our analysis of qualitative and quantitative data. Qualitative data included faculty interview data, student focus group data, syllabi, and responses to open-ended questions in the three surveys. Quantitative data include responses to closed-ended questions in the survey. Our analysis centered on the qualitative data, especially recordings and transcriptions of the faculty interview and student focus group data. Then, we analyzed the quantitative data using descriptive statistics and histograms. There were four phases of data analysis: (1) initial review of each dataset and organization of the qualitative data based on the PST framework, (2) identification of codes and coding the qualitative data, and (3) inter-rater reliability check, and (4) combination of the results of analyzing the entire datasets (including the quantitative data from the surveys) to support emerging themes.

Initial review and organization based on the PST framework

Initial review of the data included segmenting based on a central meaning of accounts, annotating each segment with a summary of the central meaning, and organizing the segments based on the PST framework. Segments refer to one or more phrases or sentences that contain one central meaning of accounts., 201 segments were identified. From the PST framework, we identified the following categories: (1) Pedagogy, (2) Space, (3) Technology, (4) Interaction between Pedagogy and Space, (5) Interaction between Pedagogy and Technology, (6) Interaction between Space and Technology, and (7) Interaction among the three.

Coding and reorganization

The second phase entailed identifying codes and coding the data based on the seven categories. For each category, appropriate codes of the category were given. For example, if Pedagogy-Space was selected for a segment, the researchers needed to select codes from Pedagogy and Space. The coding scheme was progressively developed.

Inter-rater reliability check

Around 10% of the 201 segments, 21 segments of qualitative data were purposively selected to check for inter-rater reliability. These segments were selected based on their significance to the study as containing central themes of the study findings. See the segments in Appendix F. There were two rounds of coding: (1) deciding among the seven categories based on the PST framework, and (2) deciding on codes under each category of PST. For both rounds, each of the three researchers coded the segments individually and the codes were combined and compared.

At the first round, out of 21 coded segments, the three researchers agreed on 11 segments, two of them agreed on eight segments, and none of us agreed on two segments. The researchers discussed the disagreed segments until reaching consensus on all of them. As a result, a couple of changes were made to the coding scheme during the process: (1) adding the group presentation component to the code, *class-wide discussion* in Pedagogy, and (2) creating another code, *lighting* to Space.

The researchers performed another round of coding based on the agreed PST categories. This time, the researchers were supposed to decide on a set of codes for each category. For example, if Pedagogy-Space was selected for a segment, the researchers needed to select codes from Pedagogy and Space. So, one segment was given multiple codes. Out of total of 42 codes, at least two of the researchers agreed on all. There were 28 codes that all three agreed on. The researchers discussed until reaching consensus. As a result, one change was made to the coding scheme: adding instructor-led reflection on group activities to the code, *class-wide discussion* in Pedagogy.

Approximately 78% of the qualitative data was categorized based on the PST framework. The data excluded contained introductions of the study purpose, the interviewer, and focus group participants, the interviewer's clarifying questions, and unrelated conversations. Of the 78, 24% of the elements were categorized as Pedagogy–Technology, and 20% were categorized as Pedagogy-Space. Table 4 shows all of the category percentages.

Combination of the data analysis results of the entire datasets

The final phase entailed combining the analysis results of the quantitative data into the analysis results of the qualitative data, which helped us triangulate the data. Survey questions related to each sub theme were incorporated in order to generate a rich story and valid claims. The syllabi were analyzed based on course activities, assessment structure, and course schedule to supplement the other data.

Final coding scheme

A coding scheme was developed and refined progressively during the data analysis, as a new code needs to be added. All of the codes were straightforward as they refer to specific objects. Table 5 presents the codes and corresponding definitions.

Results

This results section is organized based on the PST framework. Our discussion starts from pedagogy entailing instructional activities on a typical class day and continues how each instructional activity is supported by technology and spatial configuration of the CLS.

Table 4 Coding matrix

Category	# of Segments	Percentage
Pedagogy	39	19
Technology	12	6
Space	17	8
Pedagogy—Space	40	20
Pedagogy—Technology	49	24
Space—Technology	16	8
Pedagogy—Space—Technology	29	14
Total	202	100

Table 5 Definitions of codes

Category	Code	Definition
Pedagogy	Lecture	One way or interactive lecture by instructor
	Group activity	Small group activities or discussion among students
	Class-wide discussion	Class-wide, cross-group discussion led by instructor or students, group presentation, and instructor-led reflection on group activities performed
	Individual activity	Individual instructional activity
	Movie	Movie or other audio-visual presentation
Space	Spatial configuration	Arrangement of furniture and technologies
	Student table	U-shaped student tables
	Movable chair	Wheeled student chairs around tables
	Main station	Instructor station in front right corner of CLS, with desktop and a main display control panel
	Center	Center of the room between the two levels, with additional control panel
	Lighting	Natural lighting from windows
Technology	Video wall	Video wall in front of CLS that can be viewed as one large view, quad view, and 16 panel view
	Main control panel	Panel in the main station for control of displays
	Center control panel	Another control panel in the center of the CLS
	Push capability	The capability to push instructor desktop to student monitors or bring student desktop displays to the video wall or other displays in the room
	Displays	Video wall, two projector screens, and 16 student monitors
	Instructor desktop	Instructor's desktop in the main station.
	Instructor microphone	Wireless instructor microphone
	Instructor document camera	Instructor's document camera in the main station
	Student desktop	Student desktops on the student tables
	Student monitor	Monitors connected to student desktops on the student tables
	Student microphone	Push-to-talk microphones on the student tables
	Student document camera	Document cameras on the student tables

Pedagogy: instructional activities

Four collaborative learning patterns were identified in the 10 courses the collected data represent. Half of the courses had short lectures and group activities followed by class-wide discussion across groups. The rest had lecture and group activities with or without using computers. Table 6 summarizes the instructional flow and course structure in the CLS.

Table 6 Instructional flow in the CLS

Instructional flow	# of Courses
Lecture—group activities—class-wide discussion	5
Lecture—group activities almost daily	3
Lecture—group activities once in a while	1
Group activities—class-wide discussion	1

Lecture

In most of the courses, even where collaborative learning was prevalent, lecture was an essential instructional component. Instructors stated during the interviews that they used lecture to communicate main ideas clearly before and after group activities, framed learning content for students, and invited guest lecturers whose work was important for students to learn.

Group activities

Every course had group activities at varying frequencies. In the faculty survey, eight of 10 respondents shared that they incorporated more group activities into class than before. Group activities varied among courses. One geography course used a textbook with computer-based group activities that students completed at the end of each chapter. In another course, group activities were structured based on a specialized geographic software program. In an anthropology course, computers were used to collect and analyze data, find resources, and write a group report. Non computer-based group activities included group discussion based on discussion points or questions provided by instructors, paper-based group activities, and physical group activities where students moved around. Some group activities were daily and others lasted for several weeks.

Class-wide discussion

Class-wide discussions frequently began with a group presentation, followed by instructor or student comments. By collecting outputs from each group and combining the results, the class could compare one group's output with another, or connect group activities to the lecture through instructor or student comments. Class-wide discussion was an important component of collaborative learning, where students could reflect on their own group activities and connect their group work to the course content. Three students from two courses with no such component stated they were unsure what they learned from group activities or how group work related to course content.

Best and least ranked learning activities

Table 7 presents learning activities that worked best and least well in the CLS and the reported rationale for the responses according to the student survey. A total of 29 students responded to the corresponding survey questions, and 23 mentioned group activities as working best, while 11 students reported lecture as working least well. For the best activities, all of the comments related to technology in the room. On the other hand, the

Table 7 Learning activities that worked best and least well as reported by students

Pedagogy	Technological and spatial features	
Learning activities	Worked best	Worked least well
Lecture	n = 7 • Student monitors (4) • Video wall (3)	n = 11 • Too many screens (2) • Distracting (2) • Can't see instructor (1)
Group activities	n = 23 • Student desktops (9) • Push capability (1)	n = 1 • Being forced to do group work (1)
Class-wide discussion	n = 5 • Push capability (3) • Student microphone (1)	n = 3 • Hard to hear and can't tell who was talking (1) • Being able to interact with everyone (1)
Individual work	n = 0	n = 5 • Hard for the instructor to be on a personal level (1) • Not a proper space for individual work (1)

Note N = number of students

rationale for the activities that worked least well was complicated by factors like pedagogy, space, and technology.

Table 8 presents faculty reporting of effective room features and challenges to teaching in the room. Nine faculty members responded, with most positive comments about effective room features for group activities. Comments about challenges were mostly related to lecture.

Technology and spatial configurations for lecture

Lecture was the activity that students and faculty reported as working least well. Of the 29 respondents, 23 chose lecture to be the least well supported activity, while seven chose

Table 8 Effective room features and challenges to teaching reported from the faculty survey

Learning activities	Effective room features	Challenges to teaching
Lecture	Multiple image capability (1)	Need a pointer technology (1) Need a secondary instructor desktop in the center of the room (1) No place to see everyone (1)
Group activities	Student Tables (6) Student monitors (2) Movable chairs (2) Student desktop (1)	Need speakers at student Tables (1) Need technology that facilitates students' quick hand writing (1)
Class-wide discussion	Push capability (2) Student microphones (2)	Need technology that facilitates sharing students' handwritten notes (1) Can't spot students raising hands (1)

Note (Number of faculty survey respondents) lecture to be the best supported one. All four faculty interviewees reported difficulty with lecturing in the classroom. In the survey, one faculty member specifically mentioned that it was hard to do lecture, and five others reported room incompatibility with lecture. In addition, two students in the focus group said lecture-heavy classes might benefit more from being in a lecture hall. Overall, the technology worked well for lecture, but there were some issues with the spatial configuration of the room that made seeing and hearing lectures more difficult.

Technology

The seven students who mentioned lecture as the best learning activity cited the various display technologies in the CLS as a reason. The giant video wall enlarged lecture content for student viewing, while the student monitors displayed the lecture material up close.

Video wall

According to the student survey, the video wall was used almost every class for displaying lecture materials. The class means of the frequency question ranged from 3.7 to 4 with four being *used every class*. According to the fall 2015 faculty, all ten faculty respondents used one large view every class, mentioning the video wall was particularly great for showing a Google Earth tour, watching a movie, and close analysis of intricate work such as stitches in a textile. On average, quad view was used once in a while. One instructor used quad view every class, while three instructors used quad view once every few class periods. The 16-panel gallery view was used much less frequently.

Some minor issues with the video wall included the laser pointer now showing on the video wall, difficulty with diagramming, poor quality of projection on the video wall because of image enlargement.

Nevertheless, one instructor mentioned that the capability to draw different materials and display them made lecturing more effective, stating “I have used the multiple image capability to show fresh plant material with the doc cam on the video wall, while a power point presentation is on the student monitors.” Related to this, some faculty respondents (faculty survey, $n = 1$; fall 2015 faculty survey $n = 3$) noted they would utilize dual displays more than smaller views. One of them specifically mentioned 16-panel view being too small, and a 2×4 configuration being more optimal.

Student monitors

The majority of faculty displayed lecture materials on student monitors. According to the fall 2015 faculty survey, eight of 10 respondents did so every class and the other two once every few class periods. Students expressed mixed feelings about it depending on which display they preferred watching for the lecture material. Those preferred the video wall mentioned that having too many student monitors in view was sometimes distracting during lecture especially when students sat near the back of the CLS. On the other hand, some other students mentioned that it was one of the best features of the room. A student who preferred watching presentations on the student monitor, said “it’s definitely more vivid on the monitors themselves.” Also some students suggested having dual displays to display lecture material and group work simultaneously on their desktop monitors.

Wireless instructor microphone

A wireless microphone enabled the instructor to move freely in the room. Half of the respondents used it every class, one a few times during the semester, and four never, according to the fall 2015 faculty survey.

Spatial configuration

Spatial configuration was found to be not very compatible with lecturing. Because the CLS was designed for small group activities, there was no central location for an instructor to stand and lecture. In a lecture hall, the seats were gathered around the front of the room so everyone faces the instructor. However, in the CLS, students gathered around group tables, and the instructor walked around the tables. Consequently, there was no central place where the instructor could see everyone and be the focal point of the classroom. Five instructors mentioned this as a challenge. Two students reported another issue: Room technology was stationery and instructors could not control it while moving around. In the end, the instructors ended up lecturing from either (1) the front of the room where the main station and video wall were, or (2) the center of the room in the upper level where the center control panel was located. The black circles in Fig. 3 show the locations. However, neither spot was perfectly compatible with lecture.

The front

A major issue with the front as a lecture spot was sightline and distance from some students. Obstructive monitors made it hard to capture students' attention or spot raised hands. With student monitors in the way to the front, students also found it difficult to concentrate on the lecture (Student focus group, n = 2), one saying "all the TVs having his Power Point up and it is really distracting. I'm back there, so I see eight or nine". In addition, four students also mentioned it was hard to see their professors, who sometimes missed raised hands. Also, a student sitting in the back could not see what the professor was pointing at in the video wall.

The center

The center of the room in the upper level served as another lecture spot. Using the center control panel, the instructor could minimize the distance from students and have some level of control over the display devices. However, two problems were identified. First, being away from the main station with the instructor desktop and document camera posed a major challenge. The instructors complained that they had to go to the main station in the front of the room to change what was displayed or to show diagrams using the document camera. This disrupted the flow of the class, and two students mentioned it made the situation awkward for both instructor and students. To overcome this limitation, a teaching assistant at the main station controlled the instructor desktop during lectures as verbally directed by the instructor. However a student reported the verbal directions were distracting. Second, the instructors still had a problem of not being able to see every student or be seen by every student despite of being in the center of the room.

Technology and Spatial Configurations for Group Activities

Students and faculty rated group activities as working best in the room. Movable chairs combined with student desktops and monitors in the U-shaped student tables facilitated group activities—particularly computer-based group activities. Faculty interviewees appreciated the positive team building experience, describing the room as "a classroom environment that allowed for the teams to function as a unit interacting with other teams."

Technology

Student desktop computers

Based on the student survey, desktop computers were the most frequently used technology. Table 9 presents frequency of student computer use for group work. Forty students from five courses reported using it every class or at least occasionally. Seventy-five percent (n = 30) of student survey respondents selected technology on the student tables as an appealing room feature. Students and faculty found the desktops particularly useful for group activities such as collaborative writing or analysis, or using domain-specific specialized software programs (faculty interview, n = 1; faculty survey, n = 3; student survey, n = 9). In implementing group activities, two faculty interviewees commented that it was essential to have teaching assistants help address technical issues and keep things moving. One mentioned needing a teaching assistant for every four groups, and how peer instructors "serve a pivotal role there because they're safe in terms of asking questions…"

On the other hand, at times student desktops were not very helpful (faculty survey, n = 2; student focus group, n = 1). A faculty interviewee mentioned potential distraction from face-to-face interaction, and another mentioned incompatibility or inefficiency for group activities that involved quick sketches. A student from a lecture-heavy course was disappointed at the instructor underusing technology and not taking advantage of it for collaborative learning.

Video wall

Instructors preferred using the video wall to display one view followed by the quad view which allows instructors to simultaneously show the work of up to four groups of students according the fall 2015 faculty survey.

Half of the respondents said the video wall was somewhat yet not very effective for monitoring group activities because: (1) some preferred visiting each group in person (n = 5), (2) some were not using computer-based group activities (n = 3), (3) the 16 panel

Table 9 Frequency of use of student desktops for group work from the student survey

Discipline	Level	N	Mean	SD	Min	Max
Anthropology	100	4	3.8	0.5	3	4
Anthropology	200	1	3.0	n/a	3	3
Geology	200	3	3.7	0.6	3	4
Public health	200	17	3.7	0.5	3	4
Public health	300	15	3.7	0.5	3	4
Total		40	3.7	0.5	3	4

Note 1 Never used, *2* Rarely used, *3* Occasionally used, *4* Used every class meeting

view was too small to see (n = 1), and (4) some did not want students to look at other groups' answers (n = 1).

Other technological needs

Other comments noted needing a teaching assistant to resolve technological issues (faculty interview, n = 1), technology to facilitate quick handwriting for math types or chemical symbols (faculty survey, n = 1), and speakers at student tables to analyze audio clips. To address these needs, portable whiteboards and speakers were added to the student tables in fall 2014. Based on fall 2015 survey responses, at least three faculty respondents used portable whiteboards at least once every few class periods. This rate (3/10 = 30%) is higher than that for faculty from the chemistry and mathematics departments (4/19 = 21%). Three respondents out of 10 used the speakers at least once every few class periods (30%). This also exceeds use by the auditory course (1/19 = 5%).

Spatial configuration

Student tables

Students reported the most appealing feature of the room is group tables (n = 33, 82.5%). Students and faculty agreed that the tables made it easy to do group activities (focus group, n = 6; faculty interview, n = 2; faculty survey n = 6). A faculty member said:

The most important design element is the tables that break up a large class into many smaller clusters. This personalizes the experience at an appropriate human scale and the effect has been that students carry their engagement outside the classroom and talk to one another about what they are learning.

Students also liked that the table provided plenty of workspace and room for everyone's textbooks, notebooks, and laptops (Student focus group, n = 8) and that the U shape means everyone is facing everyone else (Student focus group, n = 2).

Other comments

Another appealing feature was comfortable movable chairs (Student survey, n = 30, 75%; Student focus group, n = 1). Some students liked being able to swivel around and look at the instructor (Student focus group, n = 3). Two instructors liked movable chairs. However, one student mentioned that there was not enough space for physical group activities where everyone had to stand up and move around.

Technology and spatial configurations for class-wide discussion

Students and faculty had mixed feelings about how the room supported it. Most were positive about technology such as the push capability and student microphones (Faculty interview, n = 3; Faculty survey, n = 4; Student focus group, n = 6; Student survey, n = 4). However, spatial configuration presented some issues with class-wide discussion (Faculty interview, n = 3; Faculty survey, n = 1; Student focus group, n = 5; Student survey, n = 1).

Technology

Push capability and video wall

The most frequently mentioned technology for facilitating class-wide discussion was the push capability. Seventy-three percent of student respondents chose it as an appealing feature (n = 29), and the five courses they represented used it occasionally as shown in Table 10. Three instructors commented that push capability was most useful for class-wide discussion and that multiple views of the video wall enabled them to see student work process and output in depth, combining results or outputs from each group, and comparing group results side by side on the video wall in the fall 2015 survey. Six students noted that seeing the differences and similarities among groups visually helped and facilitated their learning.

Eight out instructors thought the push capability was effective for comparing student work for class-wide discussion. The respondents commented that it was an efficient way to display student work (Fall 2015 survey, n = 2); made it seamless to transition from one group to another, maintaining the momentum of the discussion (n = 1); and provided a way to check student understanding, give immediate feedback, and build on the discussion (n = 2).

The one view was most frequently used, the quad view nearly as frequently used, and the 16-panel view least used in comparing student work. Two respondents specifically mentioned the 16-panel view being too small to be legible from the back. A faculty interviewee preferred quad view to 16-panel view because it was more readable during discussion. Two respondents mentioned even the quad view was distracting, one preferring a dual view with 4 by 2 configuration of the video wall, which could make the displaying content larger than in the quad view. Few instructors displayed a combination of instructor materials and student work. One instructor wanted to simultaneously project student work and instructor material side by side.

Other technologies

Other technologies for facilitating class-wide discussion included student monitors, student microphones, and document cameras in the student tables. About student monitors, some students suggested having a split screen display or dual monitors to display their own group work and the instructor's input (Student focus group, n = 2). Student microphones were used at least a few times during the semester. Student document cameras were rarely used.

Table 10 Frequency of use of video wall for presenting student work

Discipline	Level	N	Mean	SD	Min	Max
Anthropology	100	4	3.5	0.6	3	4
Anthropology	200	1	3.0	n/a	3	3
Geology	200	3	3.3	0.6	3	4
Public health	200	17	3.5	0.6	2	4
Public health	300	14	3.1	0.5	2	4
Total		39	3.4	0.6	2	4

Note 1 Never used, *2* Rarely used, *3* Occasionally used, *4* Used every class meeting

Spatial configuration

Class-wide discussions shared the same incompatibility issues as lectures. There was no centralized place where everyone could see the instructor, and where the instructor could have full control over the technologies. As one faculty interviewee pointed out, “discussion was disembodied because students could not see the person talking.” Some also said this was annoying (Student focus group, n = 5), and one of the three students who picked class-wide discussion as working least well stated this as the reason. One student suggested having a signaling lamp at each table to indicate where the speaker is.

Other comments about space and technology

Students found spaciousness of the room and natural light from windows appealing (Student survey, n = 32, 80%; n = 24, 60%, respectively). The large space made students feel comfortable and relaxed, especially with heavy technology in the room (Student focus group, n = 4). However, students sitting in the corner felt disconnected and distracted (Student focus group, n = 3), which was alleviated by their instructor walking around to check on them (Student focus group, n = 1). Some students also said the abundant natural light from windows helped them stay alert and made the class enjoyable (Student focus group, n = 4). However, poor air circulation meant the space heated up when many people were there and took a while to cool down (Faculty interview n = 2, Student focus group n = 3).

Student learning experiences

Generally, students perceived the CLS to be helpful in their learning (Student survey, n = 25), but some students felt it hindered their learning (Student survey, n = 7). Those who perceived it to be helpful commented that discussing learning content with other students and asking questions helped them learn better (Student survey, n = 14; Student focus group, n = 5). They also liked that the video wall provided visual aids for their learning (Student survey, n = 10), especially when viewing other groups’ work side by side (Student survey, n = 4). In addition, some students said they enjoyed having a different classroom set up and instructional approaches in the CLS (Student focus group, n = 3). One said, “I think it’s a nice little getaway …because all my other classes it’s just a big lecture auditorium or just a regular classroom, so this is really different compared to anything else I’ve been in.”

Three major reasons students perceived the CLS hindering their learning follow. First, the room was too large for them to connect with their instructor or students in different groups (Student survey, n = 7). These students came from classes with enrollment of 36–86. Second, some students struggled to see how group activities pertained to learning content (Student focus group, n = 1) or did not have regular class-wide discussions for reflecting on or connecting group activities to learning objectives (Student focus group, n = 3). Third, students who were in lecture only classes felt disappointed and thought it was waste of classroom resources (Student focus group, n = 2).

Students also liked when everyone contributed to group activities (Student focus group, n = 1), and when group activities did not extend outside the classroom (Student focus group, n = 1). They did not like group activities when everyone did not participate equally

(Student focus group, n = 3). There were more students who liked to stay in the same group (Student focus group, n = 6) than those who preferred switching groups (Student focus group n = 2). Those who liked to stay noted the group process became more efficient as they got to know each other and built closer relationships that extended outside the classroom. On the other hand, students who preferred switching groups said they did not want to be stuck with people who did not participate, or they wanted to make more friends or hear various perspectives.

Limitations

This study bears some limitations. First, most of the data are self-reported data. It is possible that there was some discrepancy between what participants reported and what they actually thought or did. Conducting direct observations of classes in session would have alleviated this problem. Also, direct observations may have yielded richer data on how the CLS was used and what instructional activities took place.

Second, although the faculty members were well represented, the students' response rate was low and several of the courses were not represented. Four courses out of 11 were not represented, and two disciplines that were not represented were (1) arts and science and (2) sociology. It should be noted that the findings do not represent students' perspectives from the courses in the disciplines.

Implications

The study provides a detailed qualitative description of how active learning was implemented in large undergraduate classes, and how technology and space supported it based on the PST framework. The findings of the study contribute to active classroom design and implementation.

Most active learning classrooms are designed primarily to facilitate small group activities and do not take lecture or class-wide discussion into consideration. However, a closer look at typical class activities–and the essential roles lecture and discussion play–emphasizes the importance of flexibility in classroom design. Most classes include some lecture to communicate main ideas and structure learning content, as well as small group activities and class-wide discussion to consolidate results and instructor feedback. The presence of these instructional components aligns with previous research findings for other active learning classroom models (Brooks 2012; Van Horne et al. 2014; Walker et al. 2011). Our findings are consistent with previous studies while also pointing out the challenges of class-wide discussion and lecture in large active learning spaces.

Overall, room technologies like the video wall and student desktops were perceived to be useful for lecture and class-wide discussion. Students and instructors found it particularly helpful to display multiple sources at a time on the video wall, although they thought an effective pointer would add value. Faculty and students wanted a dual display for comparing two sources in larger views on the video wall and student desktops.

The current space configuration posed some challenges for lecture and class-wide discussion, mainly with respect to line of sight. Our research findings suggest that a centralized station is essential to allowing an instructor to capture every student's attention and provide control and access to classroom displays including the document camera. A faculty member suggested having movable desks or a space in the center of the room to let students face instructors or guest lecturers, or provide some means for lowering student monitors to secure a clearer view.

Also, mobile technologies would help free up instructors and allow them to engage class in class-wide discussion from anywhere in the room. For example, a wireless mouse or keyboard would provide more control over the instructor desktop as implemented in large TILE classrooms (TILE: Transform, n.d.). A mobile application such as Doceri would support increased instructor mobility during lecture or discussion by enabling desktop control and white boarding at a distance.

To facilitate class-wide discussion, students had several suggestions such as having personal or team response systems, setting up signaling lamps at student tables, and having split or dual monitors. Personal or team response systems used in TEAL classrooms can instantaneously collect and display students responses (MIT iCampus, n.d.). Signaling lamps at student tables implemented in PAIR-UP's ALC may help students locate the speaker, preventing the discussion from being disembodied, or help instructors spot students who want to speak (Office of Classroom Management of the University of Minnesota, n.d.). Having split monitors or dual monitors lets students simultaneously view their own group work and instructor materials, as shown at Michigan State University (Lee et al. 2014).

In addition, ongoing pedagogical and technological support is needed for successful implementation that maximizes use of the space. Two instructors mentioned that one-on-one consultation sessions at CITL were helpful. One suggested having online pedagogical resources to consult instead of having to physically visit CITL during a busy semester. All faculty interviewees unanimously agreed that having teaching assistants was critical in running large classes with active learning approaches. Assistants can answer student questions, facilitate group discussion, help with spotting students who raise their hands, and controlling technology in the main instructor's station.

Table 11 Design suggestions and implementation implications

Design suggestions	Implementation implications
Flexible spatial configurations for lecture and class-wide discussion • Centralized instructor's station in a half circle configuration • Movable desks and a center space to gather around • Monitors that can retract into tables • Mobile technologies that free up instructors and enable whiteboarding • Video wall • Dual display • Pointer technology • Student tables • Signaling lamps • Dual monitors	Ongoing pedagogical and technological support • Online pedagogical resources and ideas • How to implement the ideas using the technologies • Time to explore the technologies • Teaching assistants • Spotting students raising hands • Consulting with small groups • Controlling instructor's desktop, etc.

All faculty interviewees indicated that it took some time for them to get used to in-room technologies, and the one-hour training at the beginning of the semester was insufficient. They wanted to have enough time to explore the technologies before and during the semester to figure out how to implement new pedagogical approaches. They especially wanted to figure out how to maximally utilize the video wall and push capabilities. Some students also mentioned that instructor technological knowledge helped with running classes smoothly (Student focus group, n = 4). In addition, timely technical assistance and troubleshooting were important. According to some students, if a technical issue was not fixed in time, instructors ended up doing something else and losing momentum (Student focus group, n = 2). Lastly, some faculty wanted more concrete ideas of how in-room technologies and software applications can be effectively integrated into classrooms (Faculty interview, n = 1; Faculty fall 2015 survey, n = 1). Table 11 summarizes feedback.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix A: Faculty interview questions

Semi-structured interview aimed at capturing instructor insights related to beginning of semester themes following a semester of teaching in the CLS.

Possible questions and follow-ups

We would like to hear about your experiences teaching in the CSL this semester.

1. For the class you were teaching, what do you feel worked particularly well in (or about) the room? **OR** Are there some success stories you can share with us about your teaching in the CSL this semester?
   a. What, specifically, about the room do you feel may have enhanced teaching and learning?
   b. Is there anything about the space that you think may have interfered with, or detracted from, teaching and learning?
2. What kinds of problems did you run into over the course of the semester?
   a. Were these problems able to be addressed/resolved to your satisfaction?
3. What were your impressions of student experiences in the space?
4. What kind of impacts do you think the space may have had on student learning?
   a. Were there noticeable differences between different types of learners?
5. Did you make any unanticipated changes in your approach to teaching this course, as a result of being in this space? **OR** How did teaching this course in the CSL compare with teaching the course in other spaces?

a. What was different?
b. What stayed the same?

6. What kinds of courses do you think are best suited to this space? **AND/OR** Are there courses that you think would not work well in the CSL?
7. What would make this space better? **OR** What ideas or wishes do you have for improving the CSL?
8. If you could return to the beginning of the semester and be able to teach this course over again, knowing what you now know about working in this space—would you do anything differently, and if so, why?
9. How has your experience in this space impacted your beliefs about teaching and learning?

a. How has this experience influenced your plans/approaches to teaching in more traditional spaces?

10. How would you characterize the support/training you received for working in the CSL?

a. What was helpful? **OR** What was most helpful?
b. What could you have used more help with? **OR** What could you have used more support with/for?

11. What advice would you give to instructors preparing to teach in a space like this?

Appendix B: Faculty online survey

Please focus your responses on your experiences teaching in the Collaborative Learning Studio.

1. Did you personally request to teach in this classroom?

Yes
No

2. Including this semester, how many semesters have you taught in this classroom?

1 semester
2 semesters
3 semesters
4 semesters
5 semesters
6 + semesters

3. What are you doing differently in this classroom that you haven't done (or couldn't do) in other rooms?
4. If you have changed any aspects of your teaching because of your experiences in this classroom, which, if any, of those changes have you taken back to other classroom settings?
5. Have you noticed any changes in student attitudes or behavior that you think might be attributable to this classroom or how you've changed your class because of the space?

What are those changes, and how do you think the classroom directly or indirectly led to them?

6. We built this classroom in part to test out new classroom design elements. What elements of this classroom would you most like to see carried forward into new classroom designs? Why?
7. Please share any challenges to teaching in this classroom that you think we should keep in mind as we consider renovating other classrooms.

Thank you for your valuable input. Once we compile the results of this survey, we might have more questions that would be best addressed by a focus group toward the end of the semester. We hope that you will consider joining that in-depth conversation, should you receive an invitation later this spring.

Appendix C: Student focus group questions

Focus group will be aimed at capturing student attitudes and impressions regarding both the aesthetics and actual pedagogical practices in the CLS. It will also attempt to capture implicit/idiographic theories of learning and attitudes toward collaborative pedagogy and technology use in the classroom.

Possible questions and follow-ups

We are interested in learning about the experiences of students in the new CLS space

1. Could you please describe what a "typical" day in your class is like? **OR** How does your instructor use the CLS?
    a. What other learning activities have you've participated in/experienced in the CLS?
        i. What are those activities like for you?
            1. How helpful/effective would you say they are?
2. What do you like and/or dislike about the space?
    a. Can you recall what your first impressions of the room were?
        i. What stood out to you about the room?
    b. What do you think works particularly well in the room?
    c. What isn't working in the room? **OR** What would make the room better?
3. What differences do you notice between the CLS and the other spaces you attend classes in?
    a. How might the differences you notice be impacting your learning?
    b. Are there differences in how attentive or distracted you are? If so, what do think might be responsible for those differences?
4. Are there classes you are taking that would not work in a space like the CLS? What are they, and why do you think they wouldn't work in there?

5. What experiences have you had previously with collaborative learning approaches?
    a. What were those experiences like? **OR** How did you feel about those experiences?
    b. Do you feel like collaborative approaches make a difference for your own learning?
        i. In what way? **OR** Why or why not?
6. How do you learn best? **OR** Thinking back over all the experiences you've had as a student, tell me about the class (or classes) that you feel you learned the most in.
7. How do you feel about the use of technology in classrooms?
    a. What experiences have you had with different learning technologies?
    b. What do you see as pros and cons of using technology in the classrooms?
    c. What difference, if any, has technology use made for your learning?
    d. What have been the most helpful/least helpful applications of classroom technology that you've experienced?

Appendix D: Student online survey

This survey asks about your experience in the Collaborative Learning Studio (SB015) this semester. We appreciate your honest and thoughtful responses to these questions.

1. Please select the class that you are enrolled in that meets in SB 015:

GEOG-G237, MW, 9:30–10:45 a.m.
GEOG-G110, MWF, 1:25–2:15 p.m.
ANTH-P240, W, 5:45–8:45 p.m.
ANTH-E101, TR, 4:00–5:15 p.m.
GEOG-G208, TR, 9:30–10:45 a.m.
SOC-S201, TR, 11:15 AM–12:30 p.m.
SOC-S346, MW, 11:15 AM–12:30 p.m.
COLL-C105, MW, 2:30–3:45 p.m.
SPH-H351, M, 4:40–7:10 p.m.
SPH-B150, TR, 2:30–3:45 p.m.
SPH-H220, TR, 1:00–2:15 p.m.

2. What types of learning activities worked best in this classroom?
3. What types of learning activities worked least well in this classroom?
4. Please rate the extent to which the following technology was used in the classroom.

	Used every class meeting	Occasionally used	Rarely used	Never used
Video wall for display of student work	Video wall for display of student work used every class meeting	Video wall for display of student work occasionally used	Video wall for display of student work rarely used	Video wall for display of student work never used

	Used every class meeting	Occasionally used	Rarely used	Never used
Video wall for display of lecture material	Video wall for display of lecture material used every class meeting	Video wall for display of lecture material occasionally used	Video wall for display of lecture material rarely used	Video wall for display of lecture material never used
Computer and monitor at student tables for group work	Computer and monitor at student tables for group work used every class meeting	Computer and monitor at student tables for group work occasionally used	Computer and monitor at student tables for group work rarely used	Computer and monitor at student tables for group work never used
Push to talk microphones on student tables for whole class discussion	Push to talk microphones on student tables for whole class discussion used every class meeting	Push to talk microphones on student tables for whole class discussion occasionally used	Push to talk microphones on student tables for whole class discussion rarely used	Push to talk microphones on student tables for whole class discussion never used

5. To what extent did group activities help your learning in the classroom?

A great deal
Somewhat
Not at all

This question is not applicable because we did not do group activities during class.

6. To what extent did the display of student work on the video wall help your learning?

A great deal
Somewhat
Not at all

This question is not applicable because student work was not displayed on the video wall.

7. How do you feel that the room helped or hindered your learning?

8. Please indicate which of the following is appealing to you about this classroom. (Select all that apply.)

Multiple images displayed on video wall simultaneously
Technology on the student tables
Tables that support group work
Comfortable chairs
Natural lighting
Spaciousness of the room
Attractiveness of the classroom
Other (please specify)

9. Additional comments.

Appendix E: Fall 2015 faculty survey

Thank you for agreeing to participate in our study. We are trying to learn more about how instructors use the various technologies in the CLS. Your responses will help us improve training for this room and determine what kinds of technologies should be considered for future room designs. Please base your responses on your most recent teaching experience in the CLS.

Video wall

Please indicate how often you use the video wall for the following purposes:

1. Displaying learning/lecture materials

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
One large view	○	○	○	○
Quad view	○	○	○	○
16 panel gallery view	○	○	○	○

2. Displaying or comparing student work while the class is engaging in class-wide discussion

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
One large view	○	○	○	○
Quad view	○	○	○	○
16 panel gallery view	○	○	○	○

3. Monitoring student group work while students are engaging in group discussion

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
One large view	○	○	○	○
Quad view	○	○	○	○
16 panel gallery view	○	○	○	○

4. Displaying a combination of instructor materials and student materials at the same time

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
One large view (one by one)	○	○	○	○
Quad view	○	○	○	○
16 panel gallery view	○	○	○	○

5. How effective do you think the Video Wall is for comparing student work for class-wide discussion?,

- ○ Not used for the purpose
- ○ Very effective
- ○ Somewhat effective
- ○ Somewhat ineffective
- ○ Very ineffective

6. Please explain the reason for your answer above. If not used, please explain why you did not use if for comparing student work for class-wide discussion.

7. How effective do you think the Video Wall is for monitoring student group work during group discussion?

- ○ Not used for the purpose
- ○ Very effective
- ○ Somewhat effective
- ○ Somewhat ineffective
- ○ Very ineffective

8. Please explain the reason for your answer above. If not used, please explain why you did not use it for monitoring student group work during group discussion?

9. Please share what you think is your most useful or unique use of the video wall.

Other technologies in SB015

10. How often do you push learning/lecture materials to the monitors at all student tables for the following activities?

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
For lecturing	○	○	○	○
For group discussion	○	○	○	○
For class-wide discussion	○	○	○	○

11. How often do you push student work to the monitors at all student tables for the following activities?

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
For lecturing	○	○	○	○
For group discussion	○	○	○	○
For class-wide discussion	○	○	○	○

12. How often do you use the following technologies in SB015?

	Used every class meeting	Once every few class periods	A few times during the semester	Never used
Document cameras at student tables	○	○	○	○
Microphones at student tables	○	○	○	○
Portable white boards at student tables	○	○	○	○
Speakers at student tables	○	○	○	○
Instructor's wireless microphone	○	○	○	○

Appendix F: Selected segments for inter-coder reliability check

Source	Data	Category
FI	"…the fact that they have the chance to work in class to bring things together has mitigated the tension that I felt in other courses, where I've had to say: okay, you're going to have to do some of this outside of class. Because they don't have to schedule, find a common time to do some of the integration because I provide significant opportunities in class for that to happen around the tables. And I think it also means that it's harder for people to shirk. Unless they don't come to class, they're going to be sitting at the tables and they have to be working."	PS
	"I needed a classroom environment that allowed for the teams to function as a unit interacting with other teams"	PS
	These tables seem to be conducive for people to really work together	PS
	There is no spot where everyone can see you (the instructor) well because of sightline issues (in the context of discussing doing a lecture)	PS
	It is difficult to spot students raising hands during lecture even when using only the lower level	PS
	"..the ability to get a small group of students clustered around a single station where they can collaboratively talk and work through some of the technology issues and think about the principles—both in terms of, like, problem solving on the technical side, but also thinking about the conceptual ideas behind what we're doing in class—works really well for what I'm trying to do."	PST
	After small group activities it is hard to transition away from the technology and capture students' attention because of how the room is set up, with the monitors in the way to the front of the room.	PST
	Discussion is disembodied because students can't see the person talking, although they can hear it through using the mics	PST
	Because of stationery instructor's control panel and desktop in a large space where I move around, it is difficult or cumbersome to control technology	PST
	I don't lecture much but I do need to frame things for people."	PT
	Technology sometime distracts students from face-to-face interaction with each other to exchange ideas, experiences, and perceptions. I asked them to turn off thier monitors off for those times	PT
SFG	"You are like all in your own little group and you just do things as a group, and when your group is done then you leave."	P
	all the TVs have his PowerPoint up and it is really distracting. Like, I'm back there, so I see eight or nine screens that I could look at."	PST
	a. "sometimes she'll have us create a document with pictures or something like that, and then sometimes she'll post them all on there so we can see what's on all the monitors, which is kind of cool."	PT
	She (the instructor) used Google Doc for group work and displayed it on the monitors.	PT
	I prefer watching presentation on the student monitor to on the video wall. I'd say it's definitely more vivid on the monitors themselves.	PT
	"We haven't done it a lot, but we've done it once where she was like, "Do three pictures you think of when you think of complimentary alternative medicine," or something like that, so that everyone would find three pictures and then you'd put it up. And it was cool to see the similarities between groups,"	PT
	It took a while to get used to the push-to-talk microphone when talking to the class	PT
	(The large spaces makes the student feel) "not confined, comfortable, and relaxed"	S
	Being far away in the corner of the room make them feel disconnected and distracted	S
	Abundant natural light helps students to stay alert and makes classes more enjoyable	S

Note FI faculty interviews, *SFG* student focus group

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Motivation, Learning, and Communication Preferences of Generation Z Students

Corey Seemiller

Abstract
This paper highlights communication, motivation, and learning preferences of Generation Z students, born 1995-2010, as described in the findings of a number of studies. Generation Z students are motivated most by relationships, advocating for something they believe in, and working toward achieving milestones for advancement. And, they prefer to learn independently, yet in social settings, using videos, and with passionate, knowledgeable, and caring instructors. Generation Z students prefer face-to-face communication, texting, and specific social media platforms over other communication methods.

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Learning Objectives

1) Define ways in which Generation Z students prefer and do not prefer to communicate.
2) State motivation preferences of Generation Z.
3) Describe learning preferences of Generation Z.

As human beings, we seem to love research that helps us better understand each other. Whether the research tells us about how people in different geographic regions like to vote or what people in varying occupations eat for breakfast, learning about trends of particular demographic groups fascinates us. One such area of demography is generational research, which is the study of differences in people based on their age group and stage in the lifecycle (Pew Research Center, 2015). Market researchers, social scientists, scholars, employers, and even news writers have taken an interest in generational research as evidenced by the vast information available on generations, especially the Millennial generation. Google "Millennials," and nearly 45 million results emerge. But, a new post-Millennial generation is growing up, and it seems that very little attention has been paid to them. The name commonly used for this generation is Generation Z, but they have also been referred to as Plurals, the Homeland Generation, Founders, and iGen (Sanburn, 2015). In 2014, the marketing firm, Sparks & Honey, released a report called *Meet Gen Z: Forget Everything You Learned About Millennials*, which popularized the name, Generation Z. Their report has since become a frequently cited source in many reports and publications on this generation. Throughout our studies and publications, we use what appears to be their most commonly used name, Generation Z.

In addition to the multitude of names given to Generation Z, birth years are also varied. Most reports we consulted for our research indicated 1995 as a starting birth year, whereas others used 1994 or 1996, and very few used 2000. The end year is also somewhat unclear with many studies showing 2010 and others 2012. Some even have no endpoint. Like we did for selecting a name to use in our research and publications, we chose the birth range that appeared most frequently in the other studies we consulted (1995-2010). Doing so helped us maintain consistency in comparing research findings. For studies that had slightly different birth year ranges, we ensured the birth years of the participants in the study fell into the range of 1995 to 2010.

So, what do we really know about Generation Z? First, we know that they are our entire 7-22 year-old population. And, between technological advances like artificial intelligence and nanotechnology as well as global issues such as terrorism and alternative facts, these kids and young adults are growing up during a very unique time. They do not know a world without personal digital devices like smartphones and tablets. Because of that, most have had access to nearly any information or service around the clock as long as they can remember. The oldest of Generation Z were in Kindergarten during the September 11th attacks and later were only 11 years old when we learned that global warming was an inconvenient truth. And, as they continue to come of age, they will be faced with more political, global, environmental, social, and economic issues than imaginable.

In 2014, I, along with a co-author, Meghan Grace, began a journey to uncover information about this emerging generation. Since then, we have completed two major studies, written several articles, and published a book. Our book, *Generation Z Goes to College,* includes data from several sources including findings from our *Generation Z Goes to College Study,* in which we collected quantitative and qualitative responses from more than 700 students from 15 colleges and universities in the U.S. For more detailed information about the methodology of the study, see the Introduction in *Generation Z Goes to College* (Seemiller & Grace, 2016).

Our most recent study, the *Generation Z Stories Study*, includes narrative responses from more than 2000 Generation Z undergraduate students across 47 colleges and universities in the United States (21 states), Canada (3 provinces), and Mexico (1 state). Demographic information about study participants in the *Generation Z Stories Study* can be found in Table 1.

In this study, students were asked to respond to seven open-ended questions about their perspectives, concerns, motivations, career goals, and hopes for the world. The data includes rich stories that help explain the statistics and numbers that emerged from quantitative data collected from both our earlier study and from other studies we consulted.

Although there is still much to learn about this generation, there are many great findings across our research and others' studies that can provide insight to those working with and educating Generation Z.

Table 1. Generation Z Story Study Demographics

Gender	Man: 29.34% Woman: 69.43% Transgender: 0.54% Other: 0.69%
Race/Ethnicity	African-American or Black: 6.17% American Indian, Native American, or Alaska Native: 1.73% Asian-American or Asian: 7.33% Hispanic or Latino: 10.96% Middle Eastern: .91% Native Hawaiian or Other Pacific Islander: 1.25% White: 69.93% Other: 1.73%
Annual Family Income	$0-$44,999: 22.33% $45,00-$99,999: 40.59% $100,000-$249,999: 28.41% $250,000 and higher: 8.68%
Other Variables	40.53% are receiving federal grant money for college 40.43% have taken out one or more student loan for college 35.72% are first generation college students

Who is Generation Z?

Although anyone working with tweens, teens, and young adults today might think otherwise, we found in our *Generation Z Goes to College Study* that Generation Z students see themselves as loyal, responsible, compassionate, determined, thoughtful, and open-minded (Seemiller & Grace, 2016). These characteristics are not solely reflective of their own self-image. The behaviors described in their responses to various other measurements in both of our studies showcase examples of these characteristics in action. Students shared stories of engaging in responsible behavior, being compassionate and kind to others, and being open-minded toward and embracing of difference. They made comments such as, "Deep down, we have compassion and fight for what we believe in" and "[we] are much more accepting and open-minded than the adults who raised [us]" (Seemiller & Grace, 2014). And, our study was one of many that found these characteristics among those in Generation Z. For example, Barkley & Futurecast (2017) describe this generation as one with liberal viewpoints on identity issues, but having more traditional traits such as honesty, loyalty, achievement, responsibility, determination, dependability, and independence. So, if these are not the qualities most readily apparent in working with this age group, rest assure as these might be latent characteristics that emerge as those in Generation Z enter into young adulthood.

Motivation

Generation Z has been called the most self-motivated generation ever (Bond, 2015) and are more intrinsically than extrinsically motivated (Geraci, Palmerini, Cirillo, & McDougald, 2017). More specifically, though, they are most motivated by relationships, advocating for something they believe in, and working toward achieving milestones for advancement (Seemiller & Grace, 2016).

In our recent *Generation Z Stories Study*, Generation Z students discussed relationships more than any other factor, including learning, future career, and new opportunities, as what "excites them about getting up in the morning" (Seemiller & Grace, 2017). One student in the study commented about the importance of relationships as a motivator in saying, "Life is all about relationships, and it is so important to constantly foster those relationships" (Seemiller & Grace, 2017). It is not surprising then that 75% of students in our *Generation Z Goes to College Study* indicated that they are motivated to do something if they know it will make a difference for someone, and 75% are motivated by not wanting to let others down (Seemiller & Grace, 2016). Commitment plays a significant role for this generation, as they want to ensure they follow through with others and uphold their strong sense of responsibility (Barkley & Futurecast, 2017; Seemiller & Grace, 2016).

In addition, more than three quarters of Generation Z students are motivated by advocating for something they believe in (Seemiller & Grace, 2016). They see the value of aligning their behaviors with their passions. This was evident in responses from our *Generation Z Stories Study* in which students discussed the importance of having a job they felt passionate about even at the expense of a good salary (Seemiller & Grace, 2017). Just as they are motivated by engaging in and advocating for their passions, not being able to do so might also be a de-motivator for this generation.

Finally, we found that nearly 75% of Generation Z students are motivated by receiving credit towards a larger goal or having an opportunity for advancement. Both of these findings indicate that Generation Z students strive for achievement, which is why it is no surprise that 78% of them think their drive to achieve is higher than that of their peers (Eagan, 2014).

There are many ways to motivate Generation Z students, but some methods that may seem to be useful for others are not preferred by this generation. For example, only 28% like competition with others, whereas more than 37% do not like it at all. And, only 26% prefer public recognition with more than 27% not preferring it (Seemiller & Grace, 2014). Just as it is important to utilize specific strategies for motivation, it can be just as essential to avoid those that may end up de-motivating them.

Learning

In 1993, Alison King coined the phrase, "sage on the stage" to describe a common pedagogy at the time that involved the teacher as the expert and the student as the consumer of information. She called for moving from this model toward one of active and collaborative learning where teachers instead serve as a "guide on the side." Although she was referring to the college classroom, K-12 schools also embraced this shift (Morrison, 2014). This means that for many in Generation Z, they grew up during a time in which teachers moved toward being facilitators of co-constructed learning environments. As students were empowered to engage in self-directed and peer learning, they also developed a preference for it. In the National Study of High School Student Engagement, more teens ranked individual projects (43%), individual readings (41%), and individual writing projects (37%) as very or extremely interesting compared to teacher lectures (27%) (Geraci, Palmerini, Cirillo, & McDougald, 2017).

Now as they come to college, many are used to learning on their own. And, with the vast amount of information available online, Generation Z students do not need to rely on the expert instructor, advisor, or presenter to learn new information. A student in our *Generation Z Goes to College Study* referred to the ideal learning environment as "myself and the Internet" (Seemiller & Grace, 2014). Their Do-It-Yourself mentality leads them to believe they can find exactly what they think they need to know online (Stillman & Stillman, 2017). With the continued increase in content creation, however, it is becoming more challenging to find information that is both useful and legitimate. Those in older generations might readily see this difficulty and spend time seeking credible sources. But for Generation Z, the Internet can appear to be a playground of endless quality and accurate information.

In regard to how they prefer to learn, Generation Z students like to see another person perform an action, behavior, or assignment before doing it on their own (Seemiller & Grace, 2016). For example, being able to visually see a concept being applied in a video rather than reading about it on a static web page allows them to understand the expectations needed to successfully complete the task at hand. It's no surprise then that 90% of Generation Z students surveyed in the *Generation Z Goes to College Study* indicated their primary online platform for seeking new information is YouTube (Seemiller & Grace, 2016). And, it is not just college students who find value in learning through online videos. Barnes & Noble College (2015) found that 80 percent of middle and high school students believe that online videos are helpful teaching tools. One Generation Z student exemplified this is saying, "I use YouTube mostly because there is no limit to what you can find up there like questions you may have about your computer or how to do something" (Seemiller & Grace, 2014).

Generation Z students are also intrapersonal learners, preferring independent, self-paced learning (Seemiller & Grace, 2016; Barnes & Noble College, 2015). They like to be exposed to concepts well before being asked to work with a group or raise their hand in class (Seemiller & Grace, 2016), meaning that pre-work and flipped learning would work well with them (Geraci, Palmerini, Cirillo, & McDougald, 2017). But as much as they are intrapersonal learners, liking to work independently, they are social learners (Seemiller & Grace, 2016). A student from the *Generation Z Goes to College Study* reflects this sentiment in saying, "I prefer learning in a social setting, listening and communicating with others. However, I prefer to work independently without distractions" (Seemiller & Grace, 2014).

Finally, although it may be easy in the minds of those in Generation Z to access learning on their own, they still highly value the role of the instructor. Geraci, Palmerini, Cirillo, and McDougald (2017) found that for Generation Z middle and high schoolers, teachers played a critical role in their engagement and connectedness. This seems to hold true at the college level as well in that Generation Z students like having a caring, passionate, engaging, and knowledgeable instructor (Seemiller & Grace, 2014). One student in our *Generation Z Goes to College Study* noted the ideal learning environment as a place "where the instructor truly cares about what they are teaching and shows great passion in their lessons" (Seemiller & Grace, 2014). And, for many, their preference for one-on-one learning experiences over group learning highlights the importance of the role of the instructor, as one student noted the ideal learning environment as "me being the only one in class" (Seemiller & Grace, 2014).

Communication

Although it may seem that those in Generation Z have their heads buried in their phones texting their friends, we found that in-person communication is actually the number one communication preference for Generation Z, with 83% reporting that they like it and less than 2% reporting not liking it (Seemiller & Grace, 2014). They note that being able to interact face-to-face with others provides a way to engage in both verbal and nonverbal interactions that they claim cannot be re-created through other communication channels. In fact, in-person communication was not just the most preferred method of communication, it was overwhelmingly liked, more so than the 35% who indicated liking phone calls and 29% liking emailing (Seemiller & Grace, 2014). Although they may prefer face-to-face communication, only 35% socialize in-person with others outside of school on a daily basis (Lenhart, 2012), meaning that their actual engagement in face-to-face socialization may not match their desire for it.

Not surprisingly, Generation Z students like to text (Lenhart, 2012; Seemiller & Grace, 2016), but fewer like it compared to face-to-face communication (Seemiller & Grace, 2016). The 60% who indicated liking texting say it is because it is "quick," "convenient," and "easier" to use than other communication methods (Seemiller & Grace, 2014).

Despite their preference for in-person communication and texting, those in Generation Z also like using social media. However, there are two important factors related to their social media use that can be informative. First, they are extremely private in posting, liking, and commenting, as they share on social media far less than they follow others (Seemiller & Grace, 2016). There seems to be two reasons for this. One is that they see their privacy as a security issue (Refuel Agency, 2015). They do not want to put too much information out there for everyone to see and are hesitant to engage in perma-sharing, or posting on a site in which the content never expires (Vision Critical, 2016). They also value privacy in the sense that they want space away from adults (Seemiller & Grace, 2016). One student shared this sentiment in saying, "Facebook has lost so many teen users because it went to the adults."

Second, Generation Z students use different social media platforms for specific purposes. For example, when they do share, they prefer to do so through posting images on photo-sharing sites like Instagram and Snapchat (Sparks & Honey, 2014). However, when those in Generation Z follow others, Facebook is still the platform of choice slightly over Instagram and Twitter (Seemiller & Grace, 2016). Given its versatile appeal for sharing and following, it is no surprise that 52 percent of Generation Z survey respondents indicated that Instagram was the ideal social media platform for those under 20 (Center for Generational Kinetics, 2016). But, with so many to choose from, it is not surprising to find these students with ten different accounts so they can easily shift from posting on Snapchat to reading news on Twitter to watching videos on YouTube.

Conclusion

As happens every 20 or so years, we are at a generational crossroads, one in which we transition from one generation to the next into young adulthood. Although the shift can be subtle, it is important to note that the students today are different in their characteristics, perspectives, beliefs, and styles than those in previous generations. It is important as educators and practitioners that we tap into and leverage what Generation Z has to offer in order to maximize their learning and development and help them reach their potential. ◆

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Students as collaborators in creating meaningful learning experiences in technology-enhanced classrooms: An engaged scholarship approach

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Abstract

In dealing with numerous challenges, higher education instructors need to adapt their pedagogical practices to present students with meaningful, engaged learning experiences that are likely to promote student success and adequately prepare students for the world we live in. As part of this pedagogical transformation instructors also need to consider the potential of digital technologies to assist flexible pedagogies, as well as the role that students can play as partners in transforming the learning process (C. Evans, D. Muijs, & M. Tomlinson. Engaged student learning: high-impact strategies to enhance student achievement. York: Higher Education Academy, 2015, p. 9). In this paper the author reflects on her particular engaged scholarship approach and the important role that her students—as collaborators in the pedagogical transformation process—have played in the creation of meaningful technology-enhanced learning experiences. She describes the evolution of her action inquiry approach over more than a decade and uses one particular project to highlight the value that student voice can contribute to pedagogical transformation. She also underscores the value of a "design for partnership" approach that can be incorporated as an underlying pedagogical approach to facilitate the creation of meaningful learning experiences in a technology-enhanced teaching and learning environment.

Introduction

The 21st century learning environment presents higher education instructors with numerous challenges. They are tasked with developing pedagogically sound practices that present students with meaningful, engaged learning experiences that are likely to promote student success and adequately prepare students for the world of work (Evans *et al.*, 2015; Morrison & Camargo-Borges, 2016). Additionally, instructors need to prepare graduates who are discipline specialists, as well as "independent, creative and innovative thinkers, future leaders and productive, ethical citizens who are better able to meet the challenges of living and working in our fast-changing and unpredictable world" (Zuber-Skerrit, Wood, & Louw, 2015, p. 2). In addition, instructors also need to consider context-specific challenges related to diverse student populations, large classes, insufficient institutional resources and students' under-preparedness for higher education (Hornsby, Osman, & De Matos-Ala, 2013).

Practitioner Notes

What is already known about this topic

- In the present era it is challenging but of the utmost importance to create learning environments that enhance student outcomes and, at the same time, adequately prepare students for the world of work.
- Students are motivated to learn if they "find learning activities meaningful and worthwhile and... try to get the intended benefits from them" (Brophy, 2010, p. 208).
- Digital technologies have the potential to assist flexible pedagogies and promote student agency (Evans, Muijs, & Tomlinson, 2015, p. 9).

What this paper adds

- Employs an engaged scholarship approach to provide insights regarding the impact that student-instructor collaboration (which involves deliberate efforts to motivate students to become engaged in the learning process) can have on the improvement of pedagogical practices.
- Advocates a "design for partnership" approach that can be incorporated as an underlying pedagogy to facilitate the creation of meaningful technology-enhanced learning experiences.

Implications for practice and/or policy

- Instructors need to make more deliberate efforts to "design for partnership" as part of their pedagogies rather than treating students as mere data sources.
- An engaged scholarship approach that focuses on the active involvement of motivated student collaborators can lead to the development of new knowledge and the overall improvement of student learning experiences.

In dealing with these challenges, higher education instructors need "a new understanding of teaching and learning processes and methods that maximize student learning" (Zuber-Skerrit *et al.*, 2015, p. 6), and should consider ways in which they can adapt their pedagogical practices accordingly (Morrison & Camargo-Borges, 2016, p. 162). In advancing pedagogical practices that support meaningful and engaged learning, Waring and Evans (2015, p. 27) propose "a more informed understanding of pedagogy as a dynamic process, underpinned by theories, beliefs, values, and dialogue realised in real settings". Although Evans *et al.* (2015, p. 8) recognise the importance of discipline-specific approaches to pedagogic research, they appeal to researchers to be more explicit in identifying the generic pedagogical principles relevant to a wider context. They also request further exposition of the role that students can play as more active collaborators in the learning process, as well as the potential of digital technologies to assist flexible pedagogies (Evans *et al.*, 2015, p. 9).

The aim of this paper is to illustrate the important role that students as collaborators can play in creating meaningful learning experiences and how these insights have contributed to the transformation of my own pedagogical practices. Although the paper uses one particular project as example, the reflections and conclusions are informed by data collected over a period of 13 years as part of an ongoing action inquiry (Dick, 2002) aimed at establishing guidelines for the creation of meaningful technology-enhanced learning experiences in undergraduate Computer Science classrooms.

Perspectives from literature

This section commences with a brief overview of the concept of student engagement—articulating the various components that need to be considered in pedagogical strategies aimed at fostering a meaningful and engaged learning environment. It is followed by perspectives on the impact that students—as partners in the learning process—can have on the development of meaningful learning experiences.

Student engagement

Literature presents "student engagement" as a multi-dimensional concept with an array of contrasting definitions and associated concepts. In an attempt to provide some clarification in this regard, Kahu (2013) identifies four dominant research perspectives on student engagement: behavioural (effective teaching practice), psychological (individual psycho-social process), socio-cultural (critical role of socio-cultural context) and holistic (broader view). In the South African higher education context, views on student engagement are predominantly rooted in the work of North American and Australasian researchers. Engagement is generally regarded as the frequency and enthusiasm with which students participate in educationally meaningful activities that are linked to high-quality learning and involves interaction with a wide range of stakeholders and contexts (Coates, 2008; Hu & Kuh, 2002; Krause & Armitage, 2014). This viewpoint draws elements from both the behavioural and socio-cultural perspectives—as also identified by Kahu (2013). Despite many contrasting definitions in literature, there is, however, consensus among academics regarding the importance of fostering (deeper) student engagement in higher education (Bryson, 2014a; Dunne & Owen, 2013, p. xvi; Kahu, 2013, p. 758). In an attempt to provide conceptual clarity, Bryson (2014a) proposes the separation of student engagement into two spheres: "engaging students" and "students engaging." "Engaging students" centres around the opportunities created for students (by various stakeholders) to participate in educationally meaningful ways, while "students engaging" refers to the way in which individual students participate in these educationally meaningful activities.

For students to engage, they need to become active participants in their own learning. At many institutions the disorganised way in which active learning practices are implemented has, however, been shown to negatively impact student learning (Kuh, 2008, p. 9). Coates (2008, p. 29) urges instructors to make more deliberate efforts to enhance student engagement by considering strategies that focus on enhancing active learning, as well as developing supportive and responsive learning environments. Instructors should also realise the potential value of incorporating students' views in efforts to enhance student engagement (Coates, 2008, p. 30). Such efforts should include opportunities to reflect on their learning processes and the outcomes of their learning (Barkley, 2010, p. 17).

All efforts would, however, be educationally meaningless if students were not motivated to learn. Wlodkowski and Ginsberg (2010, p. 16) regard motivation as a "consequence of learning." They encourage instructors to firstly, develop a deeper understanding of their students' different perspectives and secondly, work with their students to create a "motivating educational experience" (p. 17). They also regard true, active engagement as an indicator that students "are motivated to learn and are learning" (p. 18). Instructors are therefore "more likely to promote student engagement" when they implement pedagogical practices that "increase the synergy" between active learning and motivation (Barkley, 2010, p. 38). Any pedagogical innovations need to consider the individual needs, interests and values of students, as well as the context in which teaching and learning are taking place (Evans *et al.*, 2015, p. 12). Furthermore, in an attempt to promote intrinsic motivation, special attention should be given to strategies that promote autonomy, competence and inclusion (Barkley, 2010, p. 11).

Enhancing meaning in learning

As part of their motivational framework, Wlodkowski and Ginsberg (1995, p. 29) identify four motivational conditions that are essential to the development of intrinsic motivation for learning: inclusion, attitude, meaning and competence. In their later work, Wlodkowski and Ginsberg (2010) suggest various strategies that instructors can utilise to put these four motivational conditions into action. This paper mainly focuses on strategies that can be employed to enhance the meaning of student learning experiences.

For learning to be meaningful, students first of all need to be interested and involved in the learning process (Wlodkowski & Ginsberg, 2010, p. 100). According to Brophy (2010, p. 208) students are motivated to learn if they "find learning activities meaningful and worthwhile and... try to get the intended benefits from them". Kuh (2008) coined a number of high-impact practices that are likely to encourage student behaviours that could enhance the meaning of learning. These high-impact practices have common characteristics related to the amount of time spent on a task; the presence of student-student and student-instructor interaction regarding important matters; the level of contact with individuals from diverse groups; and the frequency of feedback on performance (Evans *et al.*, 2015, p. 11). Evans *et al.* (2015, p. 9) also highlight the importance of involving students as partners in determining what constitutes meaningful and quality learning experiences in a specific learning context and how it can best be provided.

Students as partners

Meaningful learning experiences can be enhanced when students are involved as partners in the learning process. Healey, Flint, and Harrington (2014) define this partnership as a collaboration between instructors and students "to foster engaged student learning and engaging learning and teaching enhancement" (p. 7). In order to collectively benefit from learning and working together this type of partnership should be a relationship where all participants "contribute equally, although not necessarily in the same ways" (Cook-Sather, Bovill, & Felten, 2014, p. 7). Healey *et al.* (2014, p. 7) regard "engagement through partnership" as an effective approach to student engagement that has the potential to promote more authentic engagement and educationally meaningful learning experiences for all involved. In an attempt to identify key elements of effective educational practices that are relevant to 21st century learning environments, Evans *et al.* (2015, pp. 36–37) list five themes that each contain references to some elements of student-instructor partnerships. They call for appropriate research-informed pedagogies that:

- consider the specific learning needs of students;
- are relevant to student beliefs and values;
- are sensitive to the learner context;
- encourage dialogue between students and instructors regarding pedagogical decisions; and
- support student autonomy.

Partnership should therefore be regarded as a "process of engagement, not a product" (Healey *et al.*, 2014, p. 7). Students and instructors need to work together to establish what constitutes meaningful and quality learning experiences in a specific context (Healey *et al.*, 2014, p. 20) and how this knowledge can best be applied in creating a flexible, technology-enhanced pedagogy (Evans *et al.*, 2015, p. 9). As part of their conceptual model, Healey *et al.* (2014, pp. 7–8) outline four broad teaching and learning areas in which students can act as partners: learning, teaching and assessment; subject-based research and inquiry; Scholarship of Teaching and Learning; and curriculum design and pedagogic consultancy. A successful partnership would therefore require actions such as involving students in discipline related research projects, recognising students as partners in pedagogical inquiry, considering students' teaching and learning experiences and/or ways in which they can help improve the curriculum and provide pedagogic advice (Healey *et al.*, 2014, p. 9).

In the age of massified higher education, such actions represent a dramatic shift away from the “student as consumer” perspective, as well as the traditional “sage-on-the-stage” model (Cook-Sather *et al.*, 2014, p. 7). For a partnership to be effective, all participants need to think differently about teaching and learning as a whole. In moving towards a partnership model, Cook-Sather *et al.* (2014, p. 18) suggest “start[ing] small by asking for student input on parts your course... and giv[ing] them a chance to see what happens and how it feels when they [the students] have that voice”. Student voice—as one of the key elements of partnership (Bryson, 2014b)—refers to “a range of activities that encourage reflection, discussion, dialogue and action on matters that primarily concern students”, as well as the wider educational context and community (Fielding, 2004, p. 199). Through the incorporation of student voice, instructors have an opportunity to “reposition the way that students can contribute to teaching and learning through including and valuing their perspectives and experiences and by students taking a more active role and leading activities in relationship with staff” (Jensen & Bennett, 2016, p. 42).

In consideration of the different ways in which student voice can be incorporated into a partnership model, Fielding (2011, p. 67) identifies six patterns (or levels) of partnership. These patterns provide a valuable typology for the classification of different types of interaction between students and instructors in educational partnership contexts. On the lowest level, students act merely as *data sources*—providing instructors with “passive” data about their “progress and well-being” (p. 68). This basic level of involvement corresponds to a large extent with the “student as consumer” perspective from which partnership advocates are trying to move away (Cook-Sather *et al.*, 2014, p. 7; Dunne & Zandstra, 2011, p. 4). Fielding (2011, p. 65), however, advocates for an underlying “democratic fellowship” approach driven by “personal development” (of both students and instructors) and a “shared responsibility for a better future.” On the *students as data sources* level, Fielding (2011, p. 69) advocates for a commitment from the instructor to move “beyond test data” and consider her own, as well as the lived experiences of her students (in formal and informal contexts) when making decisions regarding the improvement of educational practices. On the second level of Fielding’s model, students act as *active respondents*—participating in dialogue and discussions to help their instructors “deepen their approach to student learning and enhance the professional decisions they make” (Fielding, 2011, p. 69). This approach provides students with formal opportunities to discuss their own learning experiences and actively engage in the enhancement of teaching and learning in their learning environments. On this level, the fellowship dimension calls for the use of students’ personal knowledge and other “rich” artefacts or narratives (such as online discussion postings and video recordings) as a trigger for transformative discussions (Fielding, 2011, pp. 69–70). The third level is characterised by a greater degree of partnership as students become *co-enquirers* who are actively engaged in dialogue, discussions and formal evaluations aimed at deepening “learning/professional decisions” (Fielding, 2011, p. 67). Further progression through Fielding’s levels of partnership allows for even more student involvement with students taking on the role of *knowledge creators* with support from their instructors (level 4) or becoming *joint authors* with their instructors (level 5). Fielding’s typology extends partnership up to the sixth *lived democracy* level where there is “a shared... responsibility for the common good” together with “an equal sharing of power and responsibility” between students and their instructor(s) (Fielding, 2011, p. 72). Throughout all of Fielding’s levels, the key to successful partnership remains the presence of dignity, respect and care, as well as “its transformative effect on the lived experiences” of all stakeholders (Fielding, 2011, p. 68). Despite the many problems and challenges associated with the implementation of a partnership model, Bryson (2014b) regards partnership as “the most fruitful” and “practical” way forward for the enhancement of student engagement.

An engaged scholarship approach

Despite the various viewpoints regarding student engagement, two elements remain central (Bryson, 2014a):

- The opportunities created for students to participate in educationally meaningful activities ("engaging students") and;
- The manner in which students participate in these activities ("students engaging")—their lived experiences.

In devising these "engaging" learning opportunities, instructors need to ensure that students are not only actively involved, but also motivated to learn (Barkley, 2010, p. 38). By heightening students' interest and consciously involving them in pedagogical decisions, their learning experiences are likely to become more meaningful (Wlodkowski & Ginsberg, 2010). But the true "meaningfulness" and quality of students' lived experiences (and how it can best be provided) can only come to light when instructors are prepared to look beyond the "students as consumers" perspective towards a partnership model (Evans *et al.*, 2015, p. 9). A student-instructor partnership approach has the potential to promote more authentic engagement and educationally meaningful learning experiences for all involved (Healey *et al.*, 2014, p. 7). The level (or pattern) of an educational partnership is determined by the various forms of interaction taking place between students and their instructor(s) (Fielding, 2011, p. 67). Partnerships that are (1) driven by the lived experiences and "personal development" of all stakeholders; (2) grounded in the human needs of mutual dignity, respect and care; and (3) focus on a "shared responsibility for a better future" (Fielding, 2011, p. 65, 68) could become the cornerstone of 21st century scholarly enquiries aimed at "engaged' pedagogical transformations.

Methodology

Action inquiry/research, as an established *reflection on action* approach, is a natural way of acting, learning and researching at the same time (Dick, 2002). In the view of Hubball and Burt (2003) action research methodologies and the variety of data collection sources provide distinctive opportunities to integrate research into university teaching and learning. In addition, they provide effective strategies to develop learning communities that cross traditional boundaries between educators and students whilst enhancing professional development and pedagogy in multidisciplinary settings. The action inquiry model used in this study comprises the four stages of *plan*, *act*, *observe* and *reflect* as proposed by Kemmis and McTaggart (1988), and is often portrayed diagrammatically as a spiral of cycles. This ongoing action inquiry was initiated in 2003 with the re-planning of each new cycle as a direct outflow of the findings from the previous cycle. The experiences discussed as part of this paper mostly relate to the implementation of a flipped classroom project that commenced in 2012.

The research design in this ongoing study resembles the *engaged scholarship* approach—described by Zuber-Skerrit *et al.* (2015, p. 4) as a participatory form of action research, which is regarded as "a philosophy, a methodology, a theory of learning and a facilitation process" (p. 11). All stakeholders collaborate in thorough, systematic inquiries to create knowledge "that is more insightful, penetrating and transformative than when researchers work on their own" (p. 4). The ultimate aim of engaged scholarship is to improve learning, teaching and research through the involvement of numerous stakeholders and to add to the existing body of scholarly knowledge (Zuber-Skerrit *et al.*, 2015, p. 4).

The target population consisted of undergraduate students in the Department of Computer Science and Informatics at a South African university. The purposeful, yet comprehensive sample consisted of all students enrolled for the "Introduction to the Internet and web page development" (CSIS1664) semester course from 2003 to 2015. The number of students involved in each research cycle fluctuated between a maximum of 160 (in 2003) and a minimum of 44 (in 2007), with an average number of 89 students involved in each of the completed cycles.

In line with the requirements of a participatory form of action inquiry, the data collection methods employed were mainly qualitative (Zuber-Skerrit *et al.*, 2015, p. 14). In this way, a better understanding of students' actions, feelings, thoughts, and emotions could be developed. Most of the information was gathered by means of online feedback from the students, either as part of discussions, as messages received or as feedback on specific open-ended surveys undertaken. Other data sources included minute papers, focus group interviews and classroom discussions. The researcher (who was the lecturer responsible for presenting this course) also kept a detailed research diary from the start of the project.

The flipped classroom project

Towards the end of 2011, I noticed a sudden (renewed) interest in academically-oriented newspaper articles and online blogs about the Flipped Classroom concept [as popularised by Jon Bergmann and Aaron Sams (2012)]. As more and more academics jumped on the flipped classroom bandwagon, concerns were raised about the concept, and whether the approach was truly beneficial to student learning or just a revival of the "boring" lecture in a digital form. Student reflections collected as part of the 2010 end-of-semester course evaluations, revealed a number of shortcomings in the current technology-enhanced learning approach—especially with regard to the format of the face-to-face contact sessions and the amount of content that had to be covered in a very short time:

"*Theory classes, where the lecturer does most of the work and we are watching does not give us courage*" (Student 1).

"*The classes was nice but we should get more opportunities to do practical exercises in class*" (Student 27).

"*Class time too short for all the many concepts that needs to be covered*" (Student 45).

On reflection, I recorded the following four questions in my research diary:

1. What are the actual important information and activities that my students must know/ be able to do?
2. How can my students engage more actively in disciplinary knowledge practices?
3. How can I help my students to get there?
4. How can digital technology integration be improved to provide better support for the pedagogical objectives of this course?

Given the potential benefits of flipped classrooms (Bergmann & Sams, 2012), I decided to pilot this approach in 2012. During the planning phase I pre-recorded a series of short lecture videos and made these available to students on the institutional learning management system (LMS). Students were requested to watch these preparation videos before coming to each class session. I was hoping that moving the "boring" lectures out of the classroom would provide more time to engage students in appropriate learning activities (both individual and collaborative) during contact sessions.

The engaged scholarship approach (Zuber-Skerrit *et al.*, 2015) necessitated the involvement of my students in dialogue on my pedagogical decision to move towards a flipped classroom approach. In line with Wlodkowski and Ginsberg's (2010) engagement strategies for the creation of meaningful learning experiences, I provided all my students with frequent response opportunities to become active participants/collaborators in their learning experiences by "answering questions, giving options, demonstrating skills and reacting to feedback" (Wlodkowski & Ginsberg, 2010, p. 102). Throughout this project I have realised the value of mid-semester feedback from students. This particular type of feedback has allowed me to gather information from students relating to recent experiences and make immediate changes where necessary to further improve the students' learning experiences. Mid-semester response opportunities can be facilitated in both face-to-face settings (via minute papers or class discussions) and online environments (via online discussions or personal electronic messages). I found feedback from minute papers (Angelo & Cross, 1993, p. 148) in particular of great value to (1) elicit feedback from students regarding their experiences with the newly introduced flipped classroom approach, and (2) consequently make improvements to the overall flipped classroom experience.

After the first week of "flipping" (three classes), students were asked to share (in a minute paper distributed at the end of a class session) their first impressions of the flipped classroom approach. In general students described the approach to be "extraordinary," "helpful," "interesting," "effective," "exciting" or "different". Students commented on how the new approach forced them to "come to class prepared," allowed for "more active engagement in class activities," "improved understanding" and made it easier to "clarify misconceptions." One student expressed his complete dislike of the flipped classroom, while several others had concerns about the approach. Some students found it difficult to download the videos from home, because of a slow Internet connection, while others complained that they did not have enough time to watch the videos when made available only a day before class. Others were finding it difficult to get used to the new approach. Based on this feedback I adapted my preparation schedule to ensure that all videos were made available at least one week in advance—thus providing students with ample opportunity to schedule their viewing times. I also made a conscious effort to constantly encourage my students to watch the videos in preparation for each class.

After a further nine flipped classes students were asked to answer two questions as part of a minute paper:

- What can the instructor do to improve your flipped classroom experience?
- What can YOU do to improve your flipped classroom experience?

In their responses they urged me to:

- include more practical examples in the videos (with less focus on theoretical knowledge);
- make the practical examples discussed in the videos available on the LMS (so that they can practice by modifying and extending the examples);
- provide short exercises that they can complete after watching the videos (to help with retention);
- create an online discussion group (where students can post problems and questions); and
- give more class quizzes (to motivate students to come to class prepared).

The students also indicated that they could improve their own experiences by:

- watching the videos more often;
- attempting exercises after watching the videos;
- consulting the textbook more regularly (not just relying on the videos); and
- making notes while watching the videos.

Based on the feedback from the second response opportunity a revised "flipped" approach was adopted for the remainder of the semester. In an attempt to improve retention, students were provided with additional practice opportunities after they had watched the preparation videos. Each face-to-face session started with a quick recap of the work discussed in the videos—focusing on difficult concepts and answering student questions. While students worked on the collaborative class activities, I would move between the groups, quietly observing the students and providing comments or assistance were needed to prevent students from feeling isolated (Wlodkowski &

Ginsberg, 2010, p. 103). Whenever common areas of confusion became apparent, I temporarily halted the activity to either re-explain a difficult concept or provide advice to students on how to proceed with the activity. After class, students were given opportunities to demonstrate what they had learnt by completing individual practical assignments. An online discussion forum (created on the LMS course site) provided students with a platform where they could ask additional questions (outside of class) about problems they were experiencing while working on the practical assignments. Interestingly enough, students also started to respond to each other's online questions.

As part of reflecting on their entire flipped classroom experience, 63 of the 76 students (82.9%) completed an end-of-semester online survey. In general, they indicated that:

- Videos are more effective for content delivery than the textbook (85.8% agreement).
- Videos make it easier to participate in class activities (84.1% agreement).
- Discussions with group members (as part of collaborative class activities) helped to improve their understanding of the work discussed (82.2% agreement).
- Moving the "lecture" outside of class was beneficial to their learning experience (85.5% agreement).

The students also provided interesting insights with regard to how their preparation, and thus their learning habits and approaches, had changed during the course of the semester consequently enhancing the meaning of their learning experiences. Some "started making notes" while watching the videos whilst others adopted a similar "preparation approach" for their other courses. Since they wanted to be "more prepared and active in class" they "watched more videos," "practiced the video examples" and "prepared lists of questions and doubts" before coming to class.

As part of the end-of-semester survey, the students also provided valuable suggestions for further improvement of the CSIS1664 flipped classroom approach.

Reflection and discussion

In an attempt to engage my students in more meaningful technology-enhanced learning experiences I implemented a flipped classroom approach in the CSIS1664 course. As part of the engaged scholarship approach (Zuber-Skerrit *et al*., 2015) followed in this study, I incorporated response opportunity strategies (Wlodkowski & Ginsberg, 2010, p. 102) to encourage dialogue between myself and my students regarding my pedagogical decisions. Students were provided with ample opportunities to be "active respondents" (Fielding, 2011, p. 67) through the sharing of their lived experiences in a flipped classroom. I listened to my students and acknowledged the validity of their individual experiences, needs, values and judgments (Wlodkowski & Ginsberg, 2010, pp. 134–135). Changing the ways in which students were engaging ("students engaging") enabled me to make various adaptions to the initial flipped classroom approach and the way in which I was "engaging [my] students" (Bryson, 2014a). Students become more motivated to come to class prepared so that they could actively participate in classroom activities. With regard to the development of intrinsic motivation [as an essential element of student engagement (Barkley, 2010)], the response opportunities and consequent pedagogical adaptations not only assisted in enhancing the meaning of students' learning experiences, but it also supported the remainder of Wlodkowski and Ginsberg's (1995) motivational conditions. By caring about and showing respect for my students' individual experiences and perceptions (Bryson, 2014a; Fielding, 2011, p. 68) I was able to establish an inclusive learning environment where students felt connected to their peers, the instructor and the course (Wlodkowski & Ginsberg, 2010, p. 20). In addition, the approach helped to develop positive attitudes toward learning (Wlodkowski & Ginsberg, 2010, p. 21) by increasing the personal relevance of the learning experience (through the collaboration process) and giving students access to the learning tools and materials they felt best supported their personal learning needs. And lastly, by gaining insights on the effectiveness and authenticity of my students' learning experiences I was able to present them with a pedagogical approach that engendered competence (Wlodkowski & Ginsberg, 2010, p. 24).

In reference to Fielding's (2011, p. 67) patterns of partnership, there is ample evidence that the collaboration process described here signifies a move beyond *students as data sources* towards the *students as active respondents* pattern/level. Through my own desire to learn more about my students learning experiences, my students became active "discussants rather than recipients of current approaches" (Fielding, 2011, p. 69). In this collaboration process students were not only involved as active participants in their own learning, but they were also provided with opportunities to act as "teachers" and "assessors" themselves (Healey *et al.*, 2014, p. 8). Peer teaching was facilitated through the assistance students provided to their peers during collaborative classroom activities as well as the valuable and insightful responses they provided to questions posted on the online discussion forum. Students also had opportunities to "assess" their own work as well as those of their peers through classroom activities that required them to compare their homework answers with those of their fellow group members. Most significantly the students were directly engaged in critical reflection on existing teaching and learning practices. They were provided with opportunities to share their experiences and make suggestions for future improvement of pedagogical practices (Healey *et al.*, 2014, p. 9). Through a process that can be described as student-instructor collaboration, I was able to develop a relevant, context-sensitive and flexible research-informed pedagogy (Evans *et al.*, 2015, pp. 36–37) that provided my students with meaningful and engaged technology-enhanced learning experiences.

Although I always regarded my students as co-research partners in a scholarly pedagogical inquiry, the students themselves were not explicitly made aware of their role in this regard. Therefore, the level of student-instructor partnership described here has not yet fully moved over to Fielding's (2011, p. 70) third level—*students as co-enquirers*. What is, however, evident is the role that student voice played in enhancing the quality of learning through consideration of students' own teaching and learning experiences (Healey *et al.*, 2014, p. 9). There was also a considerable level of collaboration between myself and the students in making decisions about the process and outcome (the transformed pedagogy).

Conclusion

Although this discussion only focusses on one particular attempt at pedagogical enhancement, there are numerous other examples from this particular action inquiry where I employed similar strategies to involve my students as collaborators in my pedagogical transformation process. In comparing my current (2016) pedagogical approaches to those employed before the start of this project (2003), a definite teacher-centred to student-centred shift is noticeable. My basic pedagogy evolved from a traditional lecture-based approach to an engaged approach that relies heavily on flipped classroom principles and the innovative integration of digital technologies to provide my students with meaningful and engaged technology-enhanced learning experiences. My students have access to an optimally structured online learning environment (on the institutional LMS) where they can easily access the information they require in a format most suited to their way of learning. During class sessions they now use iPad devices to participate in carefully selected collaborative learning activities aimed at fostering deep learning and maximising their level of engagement. They are provided with opportunities to work on subject-related projects that allow for the sharing of their own experiences and perspectives. They also receive feedback on their learning activities in a format that best supports their learning improvement attempts. The specific strategies employed also helped to promote student success with throughput rates gradually improving from 51.2% in 2003 to 86.27% in 2015.

The true educational benefits of a partnership process can only be achieved if instructors realise the value that student voice can add to their pedagogical transformations and accept the validity of their students' views and experiences. Such a partnership process will, however, not happen automatically. In moving forward, there needs to be more deliberate efforts to "design for partnership" as an underlying pedagogy that moves beyond the lowest level of partnership where students are merely used as data sources. This design should outline specific strategies to: (1) create awareness and make the partnership process visible to students; (2) motivate students to become engaged partners in the learning process who take collective responsibility for the aims of the partnership (HEA, 2014); and (3) involve students as true collaborators and co-enquirers/knowledge creators/joint authors (Fielding, 2011, p. 67) who can make suggestions and co-facilitate the implementation of new ideas (Williamson, 2013, p. 8). Such a participatory model can be a strong launching pad for the idea of engaged scholarship where students and instructors work collaboratively—in an intentional, systematic, well documented and ongoing way—to establish what constitutes meaningful and quality learning experiences (Healey *et al.*, 2014, p. 20), and how digital technologies can be integrated to best support teaching and learning in a specific context. The ultimate goal should be to work towards technologically enhanced pedagogical designs that have strong theoretical foundations and engage students as true partners in the learning process. For the successful instructor in the 21st century this engaged scholarship approach should be considered more than a methodology, learning theory or facilitation process—it should become "a way of life."

Statements on ethics and conflict of interest

At the start of each action inquiry cycle students completed the relevant consent forms giving the researcher permission to use their feedback for research purposes.

Ethical clearance for this project was also granted by the Ethics Committee of the Faculty of Natural and Agricultural Sciences at the University of the Free State (Tracking number: UFS-HSD2015/0119).

To the knowledge of the author, the information and experiences portrayed in this paper do not present any conflict of interest.

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Students' Attitudes Toward Teacher Use of Technology in Classrooms

Malia M. Hoffmann & A. Y. "Fred" Ramirez

Introduction

Given the ubiquity of use the of technological devices by students today, we infer that most students do not perceive a distinction of device usage between their personal lives and school. According to a Pew Research Center study in 2012, 78% of teens owned a cell phone, 38% a smartphone, 80% a desktop or a laptop computer, and these numbers have been consistently climbing since 2007 (Wordmald, 2015).

With teens' constant connection to others through technology, it is natural that students would expect the same constant connections in school. However, that may not always be the case. Teachers are the main factor in deciding what and how technology is integrated within classrooms (Rehmat & Bailey, 2014). The age span of current teachers is far wider than that of the current iGen students who have grown up with such devices, resulting in vast differences among teachers in comfortability with the amount of technology that is integrated into classrooms (LeDuc, & Twenge, 2018).

Literature Review

Common reasons for teachers' reluctance toward integrating technology into the classroom are lack of confidence in the tools and discomfort or fear of their usage. Teachers often have fear that they will waste time or look incompetent in front of their students (Ackermann, 2001). However, one study showed that self-efficacy improved for preservice teachers when they were trained in the technological content within a science methods course (Rehmat & Bailey, 2014).

Additionally, teacher training technology as it relates to content areas can be supported by Mishra's and Koehler's (2006) Technological, Pedagogical, and Content Knowledge (TPACK) framework, thus helping build confidence within teachers for using technology in their classes. Introducing TPACK as a means to foster greater technological connections and applications to curricular content would strengthen teacher methodology courses.

Along with TPACK, Mustafina (2016) suggests that although teachers have enjoyed integrating information and communications technology (ICT) within classrooms, it is still rare that such technology is actually implemented. Mustafina's research found that teachers had a positive outlook on the use of technology, yet provided limited access to technology for students. This was even true when students showed a high level of motivation to use technology within the classroom (p. 330).

Student motivation is a reason why technology integration is encouraged in schools. Computer technology used in English as a Foreign Language classes has resulted in a high percentage of students showing more motivation (Izadpanah & Alavi, 2016). And again, in English Language Arts courses, it has been shown there is a need for teacher professional development in student-focused technology use since the learning of English increases greatly with the integration of technology in academic classes (Davidson, Richardson, & Jones, 2014).

Student-centered technologies have not only increased student motivation and academic performance, but interactive technologies can lead to differentiated instruction through which students have again shown higher motivation. Interactive technology is changing the philosophy of technological and pedagogical instruction by allowing teachers to adapt their lessons to the differing needs of students (Levin & Wadmany, 2006).

Due to this development of student-centered technologies, pre-service teacher education is able to adapt to meet the needs of 21st century students and teachers (Mulholland, 2006; Janssen & Lozaonder, 2015). Along with technology training, research is needed to analyze whether teachers are integrating the technology that they they are learning in their professional development sessions or other technology trainings in their classrooms (Rehmat, & Bailey, 2014).

However, it has been found that the number of technology trainings held and attended by teachers is not an accurate indicator of actual application within teachers' classrooms. It has been demonstrated that attendance at technology workshops given by school districts does not predict technology use within teachers' classrooms (Brzycki & Dudt, 2005), even when

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the participants were positive regarding technology use (Gibbone, Rukavina, & Silverman, 2010).

It would behoove school districts and individual schools to listen to the attitudes of students regarding pedagogy. Are teachers always the best source for knowing what is best for students and their own learning? Students within the United States are often raised to be receivers of information rather than to be consultants for education. Pajares (1992) has shared that teachers' beliefs influence teacher practice. Research is needed to identify if teachers' beliefs parallel students' beliefs when it comes to lessons in which teachers use interactive technology.

Methods

Our study took place in a predominately suburban high school located in Southern California. The city census from 2000 to 2010 saw a decrease of six percent in the White population and an increase of eight percent in the Asian population. Although Whites were still dominant, roughly 59% of the local population were ethnic minorities. The city had an average household income of $122,000.

To show the diversity of the school, both ethnicity and gender statistics are presented here. Within the specific school (there are four high schools in the district along with two alternative high schools), 36% of the students were Latino and 31% of the students were Asian. The White population of students measured 23%. The difficulty with ethnic breakdowns is that a number of students of mixed race were not counted as such. We recognize that many students identify and embrace their multiethnic backgrounds; unfortunately, for this study, such data were not available.

The school reported that 22% of the students were eligible for free or reduced lunch and an average of 96% of the high school seniors were graduating. For those students enrolled in Advanced Placement (AP) courses, almost 70% scored a three or higher on their tests. Students at this school averaged a 1560/1600 on their SAT.

Students from history classes were asked to participate in this study. Of the students who were asked, 73 completed the 17-question Likert Scale survey through Google Forms. Of the students who completed the study, 62% identified as female and 38% identified as male. The grade level break down indicated that 49% of the students were in 9th grade and 51% in 11th grade.

All questions were optional. The students were not required to answer each question before moving on to the next one. Students were also allowed to leave the survey at anytime without repercussion. Parental consent and student assent were obtained from those who were under the age of 18 years.

Results

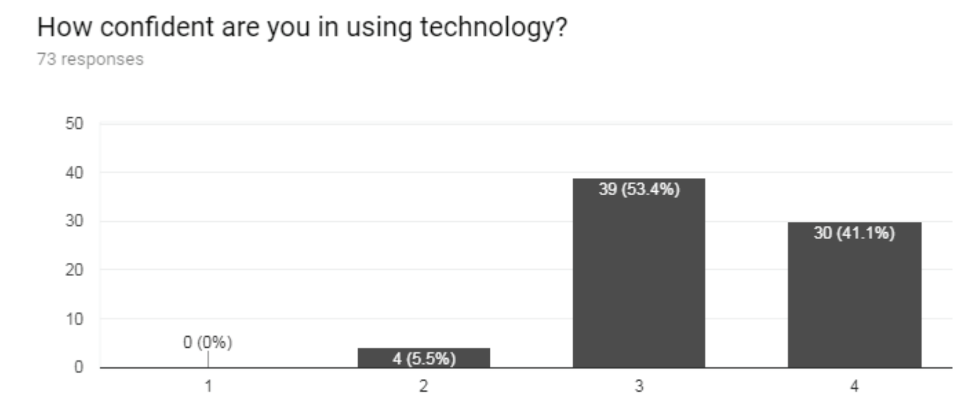
The accompanying graphs display the questions asked of the students and the responses of those who participated. Seventy-three students participated and responded to all of the questions.

Students in this study were asked about their confidence level in using technology. They were given options on a Likert Scale, 1 indicating not confident to 4 extremely confident. Graph 1 demonstrates their response to this questions. Of the participants who chose to answer this question 94.5% reported being confident.

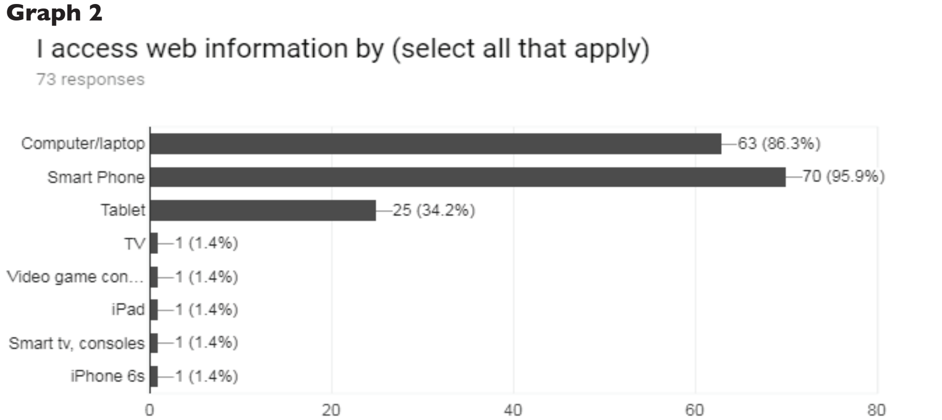
In question 2 students were asked how they accessed web information and were given multiple options as well as the option to check all that might apply. Graph 2 represents their responses. The majority of the students reported using their phones and computer/laptop to access the web.

Question 3 was intended to see how many hours students spend on social media. Graph 3 shows that 65% of students

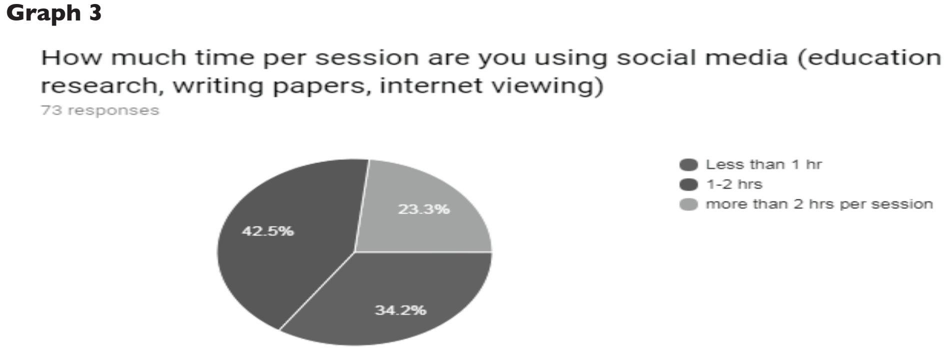
Graph 1



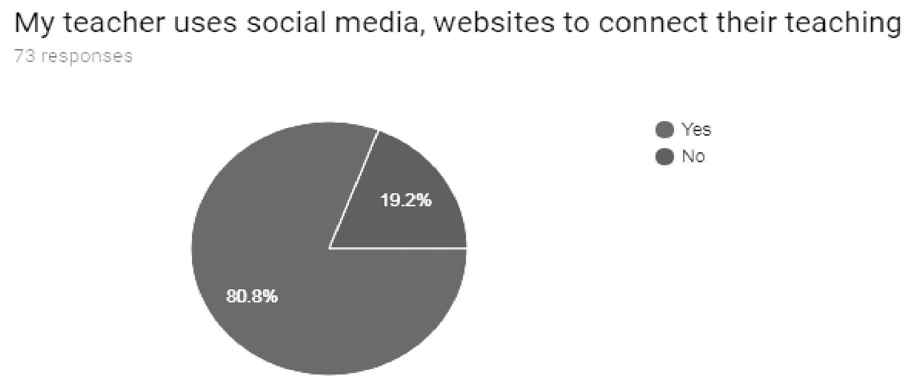
Graph 2



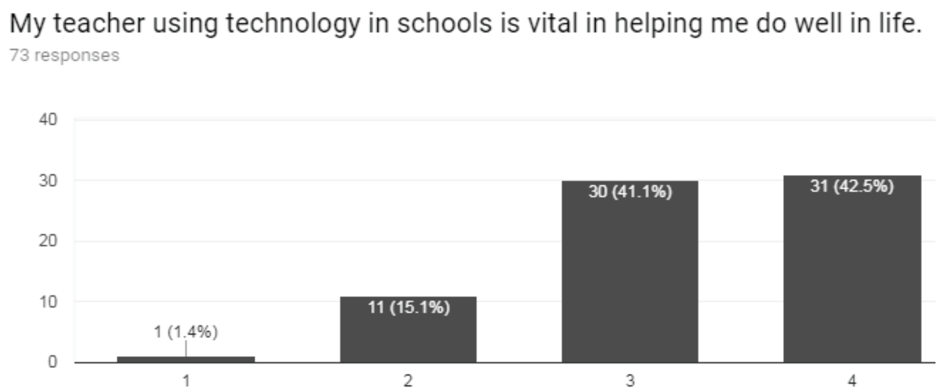
Graph 3



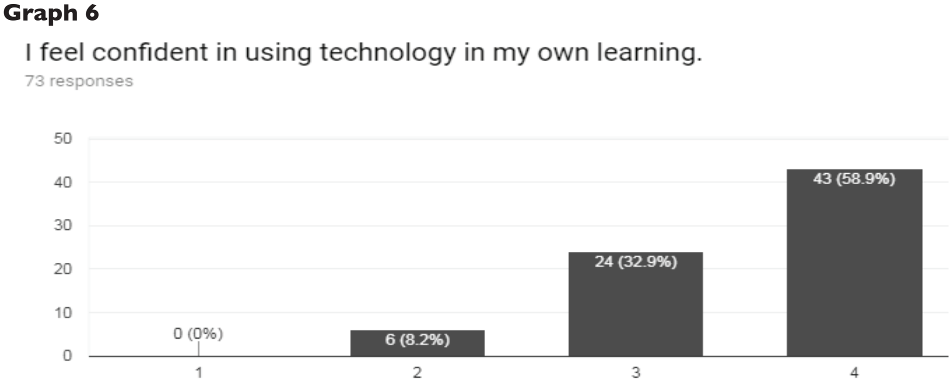
Graph 4



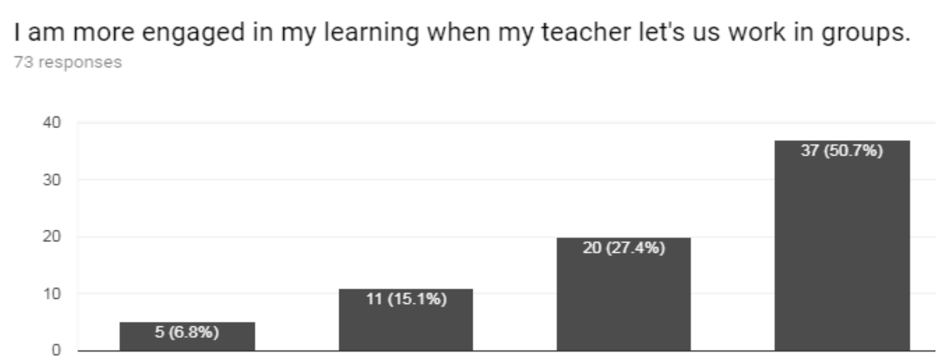
Graph 5



Graph 6



Graph 7



spend one or more hours on social media per session.

Question 4 asked students whether teachers use social media and websites to connect their teaching. Students reported nearly 20% of teachers at this school did not use social media and websites to connect to their teaching.

In question 5 students were asked to disagree or agree on a Likert Scale (1-4) with whether they believed their teacher's use of technology was vital in helping them as students do well in life. Eighty-three percent of the students believe technology use in classrooms does assist them in doing well in life.

In question 6 participants were asked if they felt confident using technology in their own learning. On a Likert Scale (1 not confident to 4 very confident), 92% reported they were confident in using technology in their own learning.

Question 7 was Likert Scaled (1 not engaged to 4 very engaged), and students were asked if they were more engaged in their learning when their teacher lets them work in groups. Seventy-eight percent felt engaged to very engaged when their teacher allowed them to work in groups.

In question 8 students were asked if they were more engaged in their learning when their teacher communicated with them using social media. In their responses 76% of students said they felt more engaged when teachers communicate with them using social media.

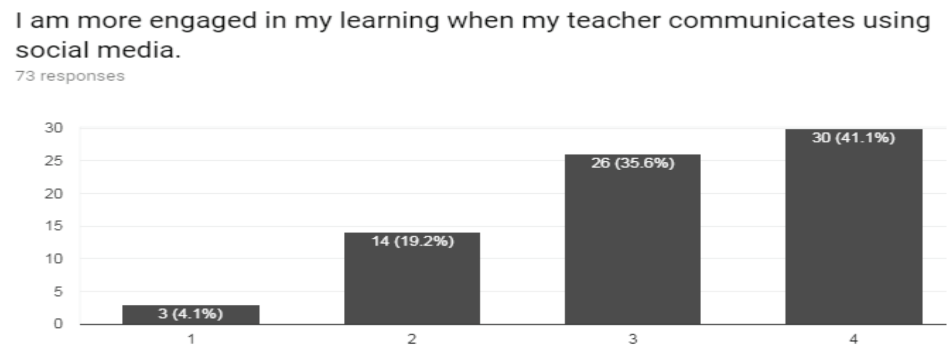
Question 9 asked students on a Likert Scale (1 not engaged to 4 very engaged) if they were more engaged in their learning when their teacher allowed them to use technology for assignments (creating movies, PowerPoints/Google Slides etc). In response, 86% of the students said they were more engaged when allowed to use technology for assignments.

With SmartPhones and the abundance of apps (applications) available, question 10 asked about students' level of engagement when teachers offered them different types of apps to use. Responses indicated 82% were engaged and very engaged.

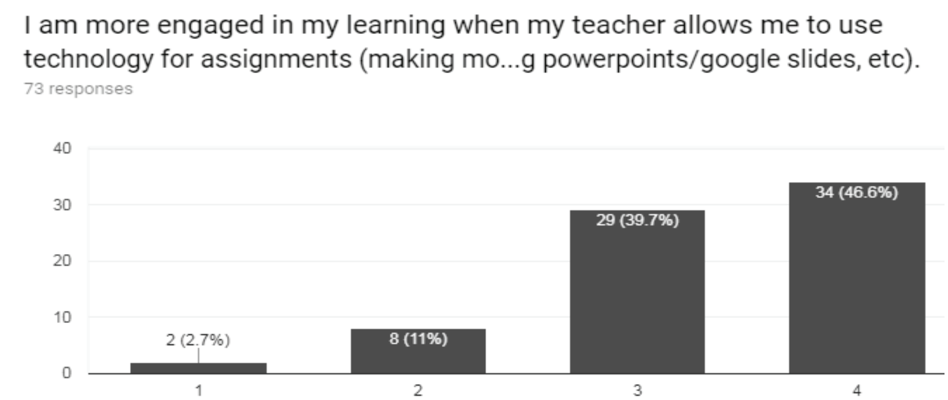
We wanted to know how many social media sites students participated in and this was asked in question 11. According to the results, 63% of students are active in three or more social media sites.

In the twelvth and final question, students were asked which social media sites they followed. Participants were told to check all that apply. Table 1 lists the five most popular social media sites and the number of students who used each of

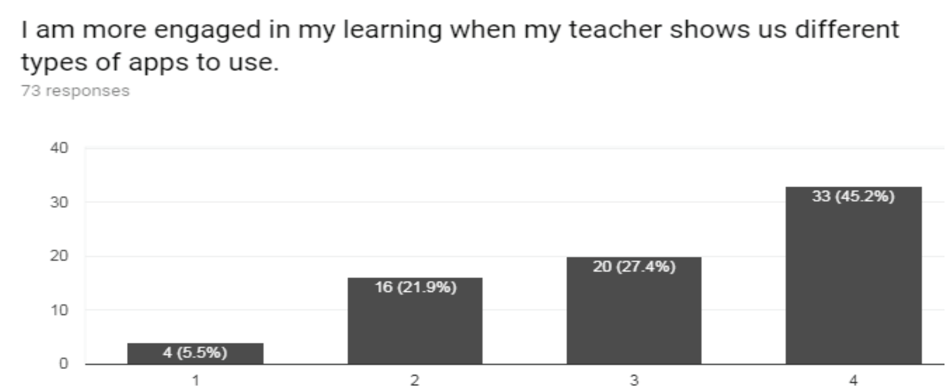
Graph 8



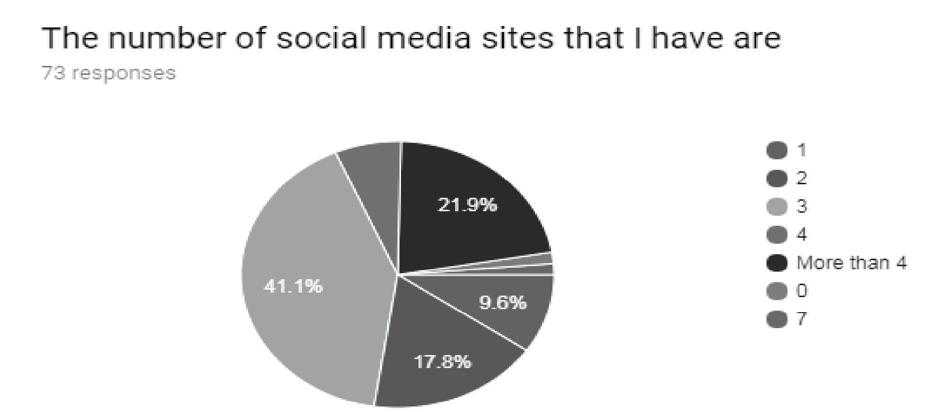
Graph 9



Graph 10



Graph 11



them. Overall, these students were subscribed to 28 different social media sites.

Discussion

We could have asked the participants how many games they have on their phone? How many apps do they use? Do they all come with instructions on how to use them? We know some do, some don't. The issue is that often teachers have an expectation of learning by having another entity—an administrator or district—show them how to do things. Yet these are things that often they, as professionals, have the means of learning on their own.

A simple Google search for teacher apps for 2017 produced thousands of hits with articles proclaiming what the Top 21 or Top 50 teacher apps were. This has been noted by Tambunan (2014), who advocates that teachers can learn on their own initiative or by asking others who may be more familiar with current technologies.

Today's teachers also have the benefit of going to Google to access the Education Training Center or to Adobe's Education Exchange to take classes and to stay current in developing technologies.

The juniors who participated in our survey were born in 2000 and 2001. When they were born, the mobile phone was in production, Internet Explorer 5 had a command on the web browsers vying for top position, Microsoft Office 2000 debuted, and Vaio introduced their new laptop (Drewe, 2014). Within four years after their birth, the students were introduced to Facebook, YouTube, and a menagerie of devices, software, apps, smartphones, and games like the Wii which arrived in 2006, and the ability to keep track of workouts just by wearing a device (BS3138, n.d.).

Therefore, by the time the students who contributed to this survey entered elementary school, many had never known life without technology. They were not learning by reading a manual or being told how to use it, rather they were learning by actually using it.

Table 1

Which social media sites do you follow?

Social Media Site	n
Instagram	57 (73%)
Snapchat	50 (68%)
Twitter	25 (34%)
Facebook	19 (26%)
YouTube	12 (16%)

Note. N=73.

The students who participated in this survey indicated they are very confident in using technology while accessing information daily from their smartphones. This should indicate to us as educators that students are comfortable using technology in navigating their learning. With the number of social media sites they are subscribed to, students from this study are connected with many people and information both locally and globally.

The students from the survey believe that teacher use of technology within the classroom is vital for their overall performance in life and indicated they thrive when teachers use technology in group work. With the onslaught of group chats, group texts, and social media platforms, today's students may be more adapt at working within a group than they are individually. When students are in groups and working on assignments, students become more attuned to the subject matter, especially when the teacher allows the content to be delivered via PowerPoints/Google Slides or by making a movie. With such advances in technology, a student is now able to record, edit, and dub music onto a created video using their phone. What does this mean for teachers and educators? It's simple, educators just need to change.

Conclusion

And many are—we are seeing more creativity from newer teachers and their use of technology. Apps such as Quizlet and Plickers were being used in classrooms while we were conducting observations for this study. Quizlet (https://quizlet.com/) is a web-based study application using flashcards for review purposes, whereas Plickers (https://www.plickers.com/) is a web-based formative assessment tool used within the classroom.

Although we have not reported on participant observations in this article, we did see that the students were passionately involved when their teacher was using Quizlet or Plickers. For students who did not have a smartphone, the teacher provided laptops from the school. In all the classes, at least one student used a laptop. All of the other students at this particular school have access to technology through their smartphones.

Throughout the lessons for each class, all students were engaged and all students were contributing to the day's assignment. As the teacher provided information, students in groups would communicate with one another while observing their phones. Students would then decide the correct answer and provide it via their devices and the answers would project onto the screen in real-time. This continued throughout the duration of the class with the teacher providing feedback when students did not provide the correct answer. The more this approach was used, the more the students became involved in their learning.

Students from these classrooms understand what they wish to have teachers do within a classroom. They have a keen sense of how they learn and how to navigate technology for answers. With students learning and creating from their smartphones, where do teachers come into play? A question to ask for the future is, how can teachers maximize such technology? What can and should the teacher's role become?

In a recent interview a systems technology educator from a private university (Tim Schumacher, personal communication, November 6, 2017) shared,

> Just this past week, I overheard a professor complain about students' use of technology within his classroom. He was irritated that they students were not listening to him while looking up information on their phones. Today's students are building their learning networks, the question is, do you [teachers] wish to be a part of their network?

Unless a teacher/professor has a tremendous gift of information or is on the cusp of research, most information taught can be Googled, sourced, and used. Today, students may obtain information in real-time from researchers in the field or from experts throughout the world. This isn't to say teachers and the teaching profession is obsolete.

Rather, what can teachers provide? Teachers can provide guidance on how students can differentiate between real and fake information. Teachers can provide formative assessments such as those being used by the teacher in the social study courses that we observed. Engagement with, rather than lecturing at the students, is what the students from this study desire. When we have a population of students entrenched in something called social media, it should be obvious the students wish to be social within their classroom and their learning.

Suggestions for Future Research

Our research was conducted in a single suburban high school in Southern California. Looking at larger populations or more urban schools could provide more insight on this topic. Future research could be explored in a case study evaluating the literature supporting technology training or professional development and seeking out guidance to actual implementation. Additionally, since students' attitudes regarding technology integration were positive, it would be interesting to study a co-mentorship between teachers and students to provide ideas for teacher-technology integration in school.

Lastly, teachers should see how they are being perceived in their tech usage. They may believe that they are being innovative with technology; however, as an example, students may not see the use of slides as innovative. Having teachers take a reflective innovative technology usage survey and compare it to students' perceptions of innovative technology use among their students could provide interesting and relevant results.

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The Design and Application of Flip Classroom Teaching Based on Computer Technology

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Abstract—The promotion and application of computer technology in the education field has been driving the continuous innovation and development of traditional teaching methods. As a new type of blended learning model, flipping classroom can be well combined with computer technology to effectively improve the quality of education and teaching in colleges and universities. he Moodle provides a good network support platform for the implementation of flipping classroom. This paper aims to develop a new flipped classroom teaching model. Supported by Moodle and adhering to the philosophy of self-learning, this teaching model arranges learning tasks according to the different characteristics and needs of learners. Through interactions, it can develop students' self-learning abilities and improve their learning efficiency; through online tracking, it can understand students' learning dynamics in time and guide them in preview of knowledge points before class to allow them to think clearly. The purpose of this paper is to study the effects of the flipped classroom teaching method based on Moodle so as to find out what to improve in this model and make it widely applied in college teaching to cultivate more applied talents.

Keywords—Flipped classroom; modular; object-oriented; dynamic learning

1 Introduction

The classroom teaching models in colleges and universities have been continuously reformed with the rapid advancement of information technology. In many local junior and undergraduate colleges, more and more attention are being paid to the cultivation of applied talents, so relevant research has been carried out [1-3]. At present, the traditional education teaching model, due to its shortcomings, cannot satisfy the needs of colleges and universities for cultivation of applied talents, thus resulting in a serious shortage of applied talents in the society. Colleges and universities should constantly explore the reform of classroom teaching models, so that students will have sufficient autonomy and say in the classroom [4-6]. Flipped classroom, being in line with the requirements of modern education reform, has provided a reference method for colleges and universities to cultivate more applied talents. At present, there are still some problems in the practice of flipped classroom in colleges and universities. For example, the limited number of experiments conducted is not enough to explain its effectiveness, students have little practice of their operational skills, and there is a lack of an online education teaching platform [7-9]. Therefore, this paper establishes a flipped classroom teaching model based on the Moodle platform and forms a learning platform in the new context. The purpose is to focus on training students' comprehensive quality, improving their abilities to discover and solve problems and think independently and promoting their self-learning and self-practice skills so as to cultivate more applied talents in colleges and universities.

2 Related theories and technologies

2.1 Flipped classroom

Flipped classroom is also known as inverted classroom, whose core idea is to enable students to learn and absorb knowledge independently, and then deepen their understanding in the classroom, which can be summarized as learning and digesting before teaching [10-12]. Its essence is to combine the traditional teaching philosophy with the information-based teaching mode, which makes full use of the extensive information and teaching resources online and the network convenience. In this model, students can use electronic devices such as mobile phones to watch online micro-classes for self-study, and then deepen their understanding of knowledge in classroom [13-15]. Flipped classroom has an irreplaceable advantage in the modern teaching. It uses videos to present refined and rich teaching content, which provides new ideas for innovation of learning methods and breaks the space limitation of teaching.

2.2 Moodle platform

MOODLE, short for Modular Object-Oriented Dynamic Learning Environment, is a service platform that enables learners to learn autonomously, exchange knowledge and think independently [16-18]. Moodle can realize course management, and allow users to upload different courses to forums, chat rooms, blogs and other platforms and discuss them [19-20]. In addition, it also allows users to share resources like assignments and questionnaire surveys, adjust their schedule of course activities and information and select the teaching time to achieve openness of the teaching information. At the same time, teachers can check the students' homepage in the Moodle environment to understand their learning progress at any time and modify and improve their curricula accordingly. Moodle is in line with the needs of colleges and universities for flipped classroom education and also easy to operate, free of charge and open, making it a world-renowned curriculum management system. Now Moodle is becoming more and more well-known in the education field in China and has been generally recognized by educational experts.

3 Construction of the flipped classroom teaching model based on the Moodle platform

3.1 Flipped classroom teaching model

At present, the inter-conversion of the learning content in and outside class is the main educational method adopted in flipped classroom. Since the ancient times, the learning tradition has been carried on in China, where teachers teach knowledge in class and students digest and understand the knowledge by completing homework or practice outside class. Flipped classroom, unlike the traditional method, allows students to learn knowledge online with the aid of electronic equipment to train their independent thinking and problem finding abilities, and then discuss the problems by themselves in class to find the solutions. Tab. 1 shows the differences between a traditional class and a flipped class:

Table 1. Comparative analysis table of traditional classroom and flipped classroom

Teaching elements	Traditional classroom	Flipped classroom
Teaching objectives	Subject knowledge	Learning ability
Teaching form	Classroom information transmission	Information transfer before class
Class content	Knowledge explanation, infusion teaching	Watch video for questions
Teaching process	Teacher teaching, students learning	Self-directed learning finds problems and leads to solutions
Technology platform	Projection display content	Network teaching platform
Teaching evaluation	Focus on academic performance	Focus on the learning process

3.2 Flipped classroom model in the Moodle environment

By referring to the educational philosophies of flipped classroom, this paper puts forward the concept of micro-class and establishes a teaching model based on Moodle, which combines the Moodle platform with the flipped classroom to maximize the advantages of both so as to better serve the learners. Fig. 1 shows the model, which mainly consists of the following modules:

In the pre-class guidance module, teachers record the class in the form of video and post it to the micro-class community section of the Moodle platform, along with a task list for pre-class preparation. According to this list, students can watch the video with directed attention and take notes in time, mark the knowledge points and digest and absorb them after class. The biggest advantage of this module is that students can conduct selective learning according to their own timetables. Before class, students will receive the courseware and the learning schedule so that they can choose the appropriate time to preview the course content.

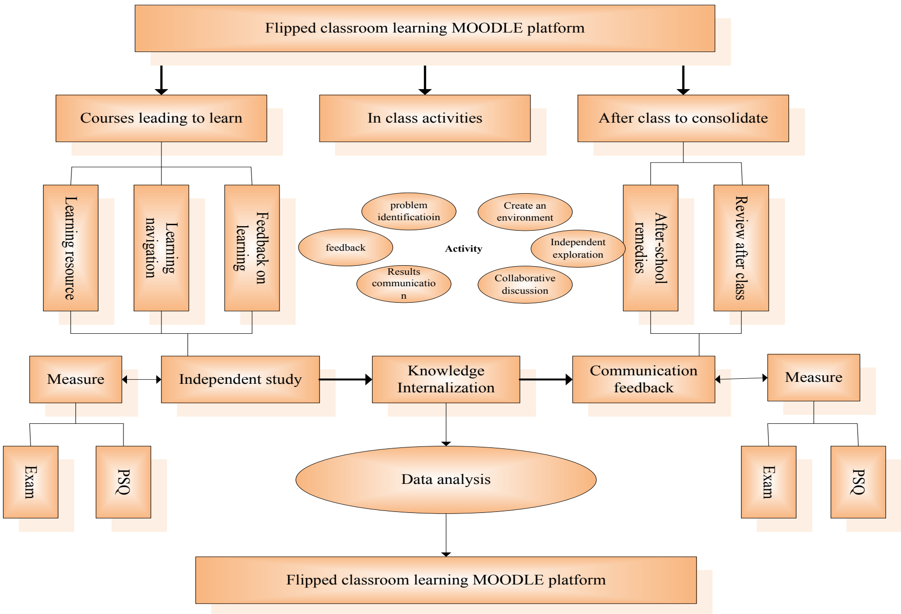

Fig. 1. Flipped classroom model in the Moodle environment

The in-class activity module is used for the process of learning and communication in the class. After previewing the content of a lesson, students summarize the problems found and then exchange and communicate with group members or teachers in different ways to find the solutions by themselves. This is to cultivate their abilities to explore independently.

In the after-class knowledge supplement module, the students rethink about the problems and deepen their understanding after class, and then summarize the knowledge points. They are also allowed to share their learning experience on the blogs on the Moodle platform to help each other digest knowledge.

3.3 Flipped classroom teaching design in the Moodle environment

The preparation of teaching content is an important precondition for flipped classroom, and also the basis for achieving teaching effects. So in order to give a class normally, it is necessary to fully prepare the content of the class.

Design of pre-class learning activities. The flipped classroom has its own teaching model. Students complete learning mainly through classroom teaching videos on the Moodle platform. The videos should target the learners' own characteristics. The key points and difficult parts should be clearly marked, and the duration of each video should be within 20 minutes. In this flipped classroom teaching model, teaching videos provided on the Moodle platform are the main way in which the course content is presented. In the Moodle environment, the model is divided into the following major modules, namely guidance and feedback, micro-class section, learning task list, selfevaluation and mutual evaluation and chat room, etc. Students can watch the teaching videos and complete the corresponding pre-class exercises. Teachers can mark the students' homework and check their learning task lists on the Moodle platform to understand their progress in learning and then based on this, help students discover and solve the difficulties they have encountered. The chat room on the Moodle platform is a place where students can communicate and discuss with each other to solve their questions they encounter during the learning process, as shown in Fig. 2:

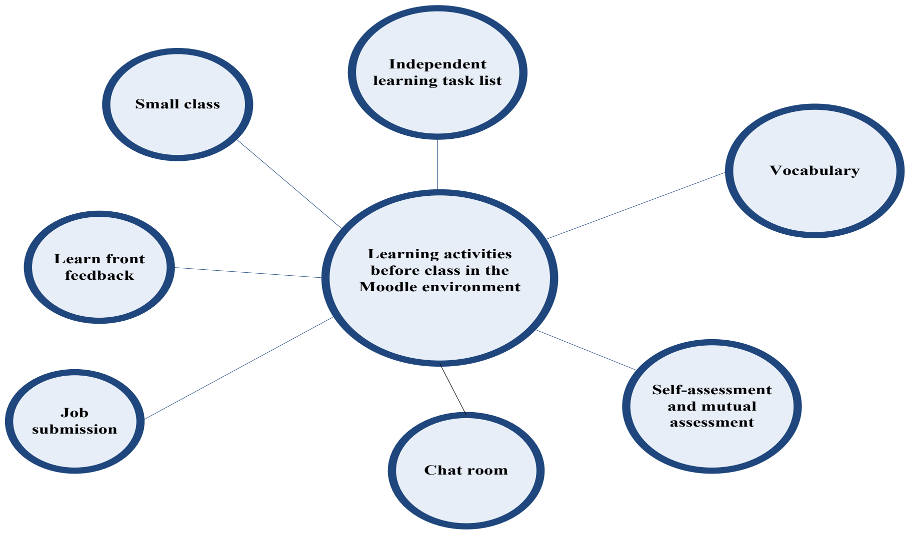

Fig. 2. Before learning module in Moodle

Design of in-class knowledge internalization activities. The first stage of the class is the feedback of questions. The Moodle platform retains the progress of the learners and the discussion of the questions. The feedbacks from students and the tracking survey of their learning progress can help teachers understand the problems students have encountered in a centralized manner so as to give general guidance. In addition, teachers can also provide individual tutoring for students according to their different problems. In the class, teachers adopt novel teaching methods and vivid teaching techniques, which greatly improves students' interest and enthusiasm in learning. See Fig. 3 for the detailed structure.

Design of after-class self-reflection and evaluation activities. After class is over, students can further consolidate their knowledge and deepen their understanding by doing the extended exercises. Teachers can evaluate students according to their learning progress on the platform, encourage students to learn from each other, and adopt different tutoring methods for different students.

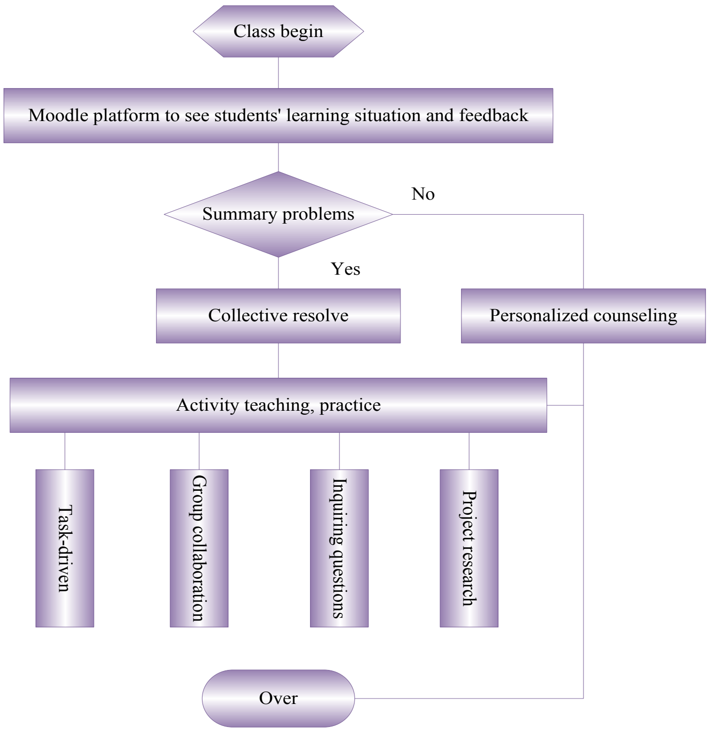

Fig. 3. Knowledge internalization activity structure design drawing

4 Design and implementation of the Moodle-based flipped classroom learning platform

4.1 Design objectives and principles

1. Overall design objectives:
   (a) High-quality teaching resources and timely release of students' learning dynamics and test questions;
   (b) Tracking and feedback of learning effects;
   (c) Unique collaborative learning space;
   (d) Novel evaluation model.
2. Design principles
   (a) Student-centered and teacher-led;
   (b) Sharing of network resources;
   (c) Diverse teaching models;
   (d) User interactivity.

4.2 Analysis of system requirements

Based on the flipped classroom education and teaching model, this paper proposes several suggestions on strengthening network platform in terms of administrator, teacher and student:

1. Administrator: the administrator has the highest authority on the system to better manage different sections, users and resources.
2. Teacher: after being authorized by the administrator, the teacher can modify and edit the content of the course, check the learning dynamics of the students, and administer the learning-related posts and teaching videos.
3. Student: after registration, students can log into their own accounts and enter the main interface, where they can select to watch teaching video, discuss courses and upload homework.

4.3 System function design

This paper fully studies the initial needs of the flipped classroom system. According to the classroom requirements and the purposes of curriculum design, the overall functional diagram of the system is obtained.

1. **Functional design for students**. In this system, the functions for students including watching teaching videos, posting their views, conducting personal information and homework management, taking pre-class tests, checking and verifying information and completing related questionnaires.
2. **Functional design for teachers.** Teachers play an important role in the flipped classroom teaching model, so they are given high requirements in this system design. To support the "teacher-led" concept, the system should have the following functions: course management, questionnaire survey, information inquiry, personal information, chat room management, resources management, homework assignment, test management, database management and chat management.
3. **Functional design for administrator.** The administrator has the administrative rights to administer the Moodle page of the users and the related announcements issued by the learners, review the contents of different sections, and make timely revisions to the announcements. The administrators have authorities to manage settings, courses, logs and files.

4.4 Database design

The design of the database is the most important part of the system. The database should be able to integrate resources, testing and homework discussion data. The design elaborated in this paper mainly includes related concepts and data tables.

Conceptual structure design. Conceptual structure design is the most important part of database design, which mainly includes information modeling. E-R is a commonly used model. The E-R diagram of this system is shown in Fig. 4:

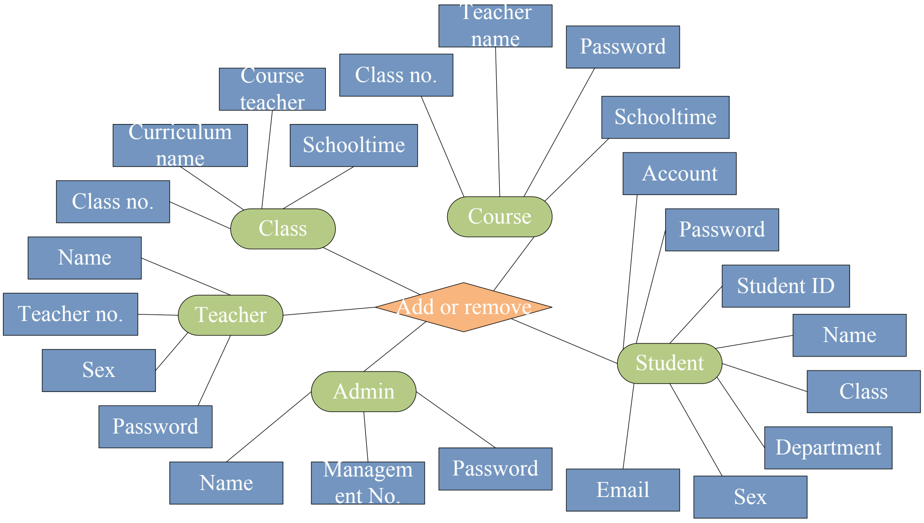

Fig. 4. The global E-R diagram of Moodle platform

Basic datasheet design. The database design of the Moodle system sets the corresponding primary keys by establishing the system tables, and sets the corresponding index with the relationships between the data tables. Tab. 2 is a data table in the system.

Table 2. The database tables involved in this system

Data table	Function
Admin	Administrator information
Teacher	Teacher information
Student	Student information
Course	Course information
Classes	Classes information
Material	Learning information

5 Implementation of the Moodle-based flipped classroom learning platform and teaching evaluation

5.1 Configuration and setup of the Moodle development environment

The basic language of Moodle is PHP. Moodle cannot be operated without the support of important software, such as servers, PHP environment and database services. This paper selects the development kit downloaded from the official website of Moodle to set up the platform.

5.2 Key technologies of Moodle secondary development

The online teaching is carried out in the context of a wide-area network. In order to better carry out teaching and provide more convenience, this system uses the B/S mode to maximize the use of the browser technology. Fig. 5 is the overall structure diagram:

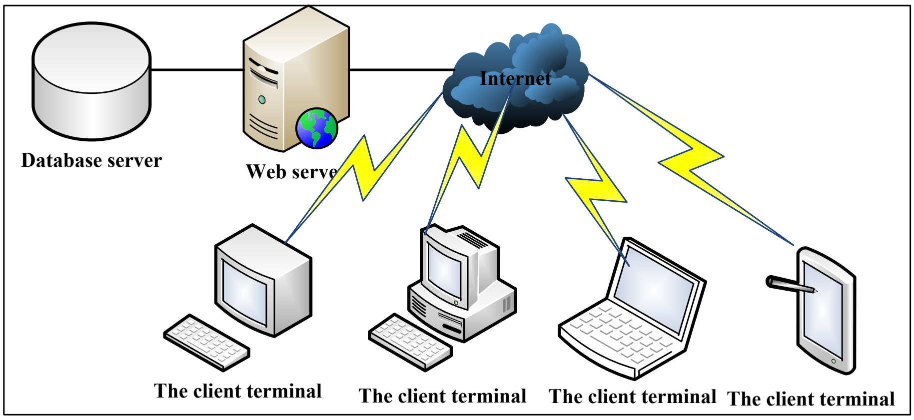

Fig. 5. The overall architecture of the system

The folder Theme is used to save the themes of Moodle. Different folders have different themes, so writing the code of each file is to develop the theme. Relevant codes are as follows:

```
'base' => array(
'theme' => 'orangemood',
'file' => 'general.php',
'regions' => array('side-pre', 'side-post'),
'defaultregion' => 'side-post',
),
'general' => array(
'theme' => 'orangemood',
'file' => 'general.php',
'regions' => array('side-pre', 'side-post'),
'defaultregion' => 'side-post',
),……
```

5.3 Implementation of the Moodle main interfaces

The Moodle platform will enter different interfaces according to the specific operator. Click the shortcut button of "Login the site" on the main page, the login page of the teaching platform will automatically pop up, presenting two different login methods, namely "sign up for a new account" and "browse as a visitor". The specific interface is shown in Fig. 6:

Fig. 6. Flipped classroom learning platform based on Moodle environment

This module has the function of protecting the security of user information. It can identify unauthorized users and restrict their login. Users who have already registered can only use their own accounts and passwords for authentication. In addition, users can also modify their own information, such as profile photo.

5.4 Effectiveness evaluation

There are generally two criteria for the evaluation of educational effects, namely the learning process and the result. Students' enthusiasm in participation and learning abilities and how they master the knowledge are part of the learning process, while the grade evaluation outside class is part of the learning result. The statistical results regarding the advantages of the flipped classroom teaching method are shown in Fig. 7:

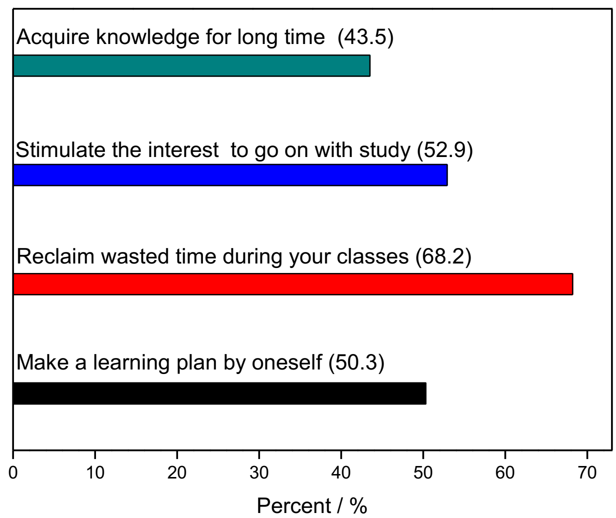

Fig. 7. Statistical learning advantages

Through the flipped classroom teaching model, 50.3% of the students increased their initiatives in learning. In addition, 68.2% of them improved their practical abilities through classroom teaching; 52.9% developed a great interest in learning; and 43.5% improved their understanding of the knowledge points through this model. Therefore, the flipped classroom teaching method based on the Moodle platform is very effective.

6 Conclusions

1. This paper establishes a flipped classroom teaching model based on Moodle and conducts in-depth studies on this model, providing a reference for the application of flipped classroom.
2. Through the functions of the Moodle platform and the flipped classroom concept, this paper designs and modifies the flipped classroom learning platform based on Moodle, which well integrates online teaching and flipped classroom to improve related services.
3. At last this paper verifies the various factors in the Moodle environment, and the verification results show that the flipped classroom can arouse students' learning interest more than the traditional method. It can help continuously cultivate students' comprehensive quality, including their understanding of knowledge as well as problem-finding and problem-solving abilities.

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