Systematic Review of Technology Enabled Active Learning Classrooms in Higher Education

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***Abstract*—Technology enabled active learning classrooms have become a prominent blended learning environment that has been highly recommended for mass expansions and normalization in higher education. Early research on the topic has shown that the environment offers good potential for increasing student engagement and learning achievement in higher education. However, no literature reviews have summarized the available knowledge documented in existing research. This study presents a synthesis of comparative research [1-12] which examines the technology enabled active learning classroom in higher education.**

Keywords—Active Learning Classroom, TEAL, ALC, literature review.

I. Introduction

In the "Active Learning Spaces" special issue of *New Directions for Teaching and Learning*, Robert Beichner described a rationale for the emergence of classrooms that emphasize technology enabled active learning. This rationale can be synthesized by the changing of both society and students. First, the simpler assertion is that society is changing in ways that are making information very easily accessible. These changes serve to undermine traditional academic authorities and the faculty monopoly of information in the classroom. Second, the modern information society is shaping students to be vastly different than in the past. Beichner suggested that "Technology has literally changed the way students think. People are often better at remembering how to find information than recalling the information itself. In a very real sense, our cognition is evolving" [13]. Additionally, it was proposed that "Today's students are used to an expect continuous connection to information and people. Forcing them to put their personal technology away during class contradicts the way they live their lives and gives students one more reason to expect that what they learn in school will have little relationship to reality" [13].

Despite a long history of active learning pedagogies, research focusing on technology enabled active learning in classrooms is a recent phenomenon, particularly as it relates to the ALC. To my knowledge, no systematic literature review has been conducted for the topic. Consequently, research and literature discussing this topic are scattered among interdisciplinary journals and being described with a variety of different terms throughout different regions of the world. Thorough reviews of previous literature provide an effective means for establishing the foundations of knowledge, describing the key concepts, facilitating theory development, and identifying paths for future research that is needed to strengthen the research field [14].

The main purpose and contribution of this literature review were to: (1) outline past research to synthesize results describing learning outcomes in comparative settings; and (2) showcase academics that have called for research on this topic to highlight research gaps that emerge from the synthesized literature. This study presents a synthesis of research scattered across the domains of communication and educational computing to expedite future research on this important issue in higher education.

II. Methodology

The search procedures for identifying relevant literature were based upon Webster and Watson's [14] three-step recommendation for conducting a systematic review. The three-step process consisted of: (1) identifying the major contributions that exist in prominent journals, (2) tracing research chronologically backward in time to identify other related articles that should be considered by reviewing the citations of the previously identified prominent journal articles, and (3) expanding the review forward in time by using the key phrases commonly identified among the previous research to search among a variety of databases to extend the breadth of publication coverage. This procedure was recommended to support a complete review which is not arbitrarily constrained to a specific research mythology, type of journals, or geographic area [14].

A. *Identifying Major Contributions*

After months of researching the topic, eight major contributions were identified among prominent research journals, including The British Journal of Educational Technology [8], Computer & Education [12, 15], Computers in Human Behavior [16], EDUCAUSE Quarterly [4], Journal of

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Learning Sciences [1], and Learning and Instruction [17]. In addition, a consistently mentioned research project, the Student Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project [3], was identified as being critical to this research field within the first phase of the search procedures.

B. Tracing Research Chronologically Backward

The reference lists of previously mentioned major contributions were examined to trace research chronologically backward from the most prominent papers. To further clarify this process, the approach has also been described as a "snowball search" [18]. Based upon careful exploration of the eight reference lists, 33 related articles were identified and preliminarily archived for this literature review. Step-two entailed reading the articles, as well as utilizing Google Scholar to identify articles with high citation frequencies. Related articles that were well-written or highly cited had their reference lists further examined to expand the depth of the archive being developed on this topic.

C. Expanding the Search Forward

Based upon the knowledge obtained through the processes of step-one and step-two, several commonly used terms were identified to describe the phenomenon. The following search phrase was developed and used based upon these commonly identified terms:

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"active learning classroom" OR "ALC" OR
"technology enable active learning classroom" OR
"technology enhanced active learning classroom" OR
"TEAL" OR "smart classroom"
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Three databases were selected to provide coverage of a wide variety of indexes within educational and multidisciplinary domains. The selected databases were Academic Search Complete (requires subscription), the Educational Resource Information Center (ERIC) (Free), and the Directory of Open Access Journals (DOAJ) (Free). Academic Search Complete is a multidisciplinary and international database produced by EBSCO Publishing that provides access to more than 6,000 peer-reviewed journals, including nearly 4,000 indexed in the Web of Science or Scopus, and over 6,600 full-text magazines and newspapers [19]. ERIC is an educational database produced by the United States Department of Education containing over 1.3 million records dating back to 1966 [20]. DOAJ is a multidisciplinary and international database maintained by Lund University (Sweden) containing more than 11,000 open access journals [21]. When utilized together, it was believed that these databases would uncover publications from a wide variety citation indexes, content sources, countries of origin, and differing perspectives.

The Web of Science was purposefully not selected as a database for this literature review for two reasons. First, through implementing Webster and Watson's [14] three-step review process, significant effort was exerted during the first two steps which was believed to support data saturation naturally over an extended period of research. Therefore, it was considered unnecessary to employ a metaphorical "search net" as large as the Web of Science during the third phase of the literature review, as it was likely to result is high rates of redundancy or irrelevant search results that did little to change an already somewhat saturated picture of the topic. Second, the first two steps of the review identified several key publication sources that were not listed within the Web of Science. For example, EDUCAUSE Quarterly and the Journal of Learning Spaces were not indexed with the Web of Science. Two unlisted books were also identified as central and critical for describing this topic, including New Directions for Teaching and Learning (provided 10 relevant chapters) [22] and Research-based Reform of University Physics (described the START-UP Project in detail) [3]. Thus, it was strategized that the three selected databases in combination with the "snowball search" procedure would be the most efficient way to identify the major research contributions related to this particular topic.

When utilizing the search phrase, two constraints were added to identify only 'peer-reviewed' and 'English' manuscripts. As illustrated in Figure 4, step-three provided 218 search results between the three data bases. Upon combining the results, 89 relevant articles were identified after 22 duplicates were removed. The percent of relevant publications among ERIC, Academic Search Complete, and DOAJ was approximately 31%, 50%, and 55%, respectively. The relevant search results were then individually examined based upon the following criteria:

- Research must be empirical examination of the ALC environment.
- Research must be comparative between the ALC and traditional face-to-face classroom contexts.
- Research participants must be enrolled in formal higher education institutions.

Among the 89 relevant studies identified, 12 studies met the above mentioned selection criteria. Previous research has utilized activity theory as a framework for documenting the data of literature reviews [23]. Therefore, based upon activity theory and the conceptual and theoretical framework of the present dissertation, the 12 selective studies were examined based upon their respective (1) subjects, (1) objects, (3) mediating artifacts, (4) rules, (5) community, and (6) division of labor.

D. Synthesizing the Results

1.) Documentation of Data based on Activity Theory

Activity theory was selected to be the basis of evaluating the research. Activity theory is important because provides a classification system to describe the different aspects of human activity. Activity theory suggests that human activity systems consist of six main aspects, including subjects, objects, mediating artifacts, rules, community, and the division of labor. The 12 selected studies are summarized in Table 1 and Table 2. Table 1 documents the subject and object data aspects of activity theory. Table 2 documents the mediating artifacts, rules, and community data aspects of activity theory. In most cases the selected studies provided some information relating to the six components of activity theory. However, some articles lacked relevant information to describe a certain component, usually because that activity theory component was outside the scope of research in the selected study.

TABLE I. DOCUMENTATION OF SUBJECT AND OBJECT DATA

ID	Subject			Object
	Degree Status	***Treatment (n)***	***Control (n)***	***Learning Outcomes***
1	Undergrad	Sem1=176 Sem3=514	Sem2=121	Treatment showed significant improvements in conceptual understanding.
2	Undergrad	120	52	Treatment showed significantly higher retention of knowledge 12-18 months after course completion.
3	Undergrad (N = ~15,000)	Not specified	Not specified	Treatment increase conceptual understanding, particularly among women and minorities.
4	Undergrad	160	108	Treatment grades significantly exceeded prediction by ACT scores. Control grades were as predicted.
5	Undergrad	Sem1=49 Sem2=194	Sem1=97 Sem2=253	No difference observed during first semester. Treatment showed significant learning gains during second semester.
6	Undergrad	Sem1=252 Sem2=238	Sem1=90 Sem2=72	Treatment showed significant learning gains during first semester. Both showed similar learning gains second semester.
7	Undergrad (N = 349)	Not specified	Not specified	Treatment grades significantly exceeded prediction by ACT scores. Control grades were as predicted.
8	Undergrad	42	41	Treatment grades significantly exceeded prediction by ACT scores. Control grades were as predicted.
9	Undergrad	192	108	Not within the research scope
10	Undergrad	102	161	Treatment grades significantly exceeded prediction by ACT scores. Control grades were as predicted.
11	Undergrad	246	182	Not within the research scope
12	Undergrad	Sem1=340 Sem2=314	Sem1=340 Sem2=340	Treatment showed significantly higher scores despite 66% reduction in face-to-face classroom time.

2.) Learning Outcomes in Comparative Settings

A thorough review of the 12 selected studies provides some compelling evidence suggesting that ALCs can improve students' learning outcomes in setting which employ mediating artifacts of both basic ICT as well as advanced programs and software. Ten of the twelve comparison studies examined cognitive learning outcomes. Research shows that the ALC can result in students significantly exceeding course grade predictions based upon ACT scores [4, 7-8, 10], significantly increased level of conceptual understanding [1, 3], and result in significantly higher knowledge retention twelve to eighteen months after course completion [2]. In some cases, it was documented that the positive influence of ALCs were more strongly realized among women and minority students [3, 6] and the environmental conditions assisted in reducing positional discrimination among students [11]. Additionally, [12] reported findings of significantly higher achievement among students learning in the ALC even when face-to-face classroom time was reduced by two-thirds and supplemented by a flipped classroom blended learning approach.

Two studies [5-6], both of which were positioned in China, reported mixed results over a two semester durations of time. For example, finding no difference during the first semester, and significantly higher levels of learning in the ALC the second semester [5]. The follow-up comparative studies showed the opposite, whereas, the first semester reported significantly higher learning with the ALC and the second semester showed no difference [6]. The first set of findings may be explained by the somewhat radically different atmosphere and approach of the ALC. Students from China may not have been initially comfortable with the learning context, and therefore, required a period of adjustment to acclimate and begin reporting similar positive outcomes to the research that has been conducted in the United States. The authors explained the second set of finds with respect to students' out-of-class study habits. Focus group interview described the control group of students as spending more time studying outside of class than the students participating in the ALC. These findings are important because they highlight that regardless of the technology or pedagogies employed, students personal interest and regulation toward their learning is an important factor that influences cognitive learning outcomes.

3.) Highlighting Calls for Research

A variety of authors have proposed questions to direct future research with ALCs in higher education. For example, [12] suggested more research is needed to understand how to optimize time in the ALC and students' exposure in ways that allow for the environment to be most effective for students' learning. [8] posed a similar series of questions extending this notion in a way that primarily emphasizes the need for understanding the influence from the spatial design of ALC contexts. The specific questions posed include the following:

- What characteristics of formal physical spaces contribute to the accelerated pace of learning in an ALC?
- How do the formal learning spaces affect students' perceptions of their learning experiences?
- Do students respond differently to the contributions of formal learning environments based on demographic characteristics, course level, or subject matter?
- How does the space constrain or facilitate faculty teaching practices and behaviors?
- How does variation in those practices and behaviors caused by variation in formal spaces shape student engagement? [8].

TABLE II. Documentation of Mediating Artifacts, Rules and Community Data

ID	Mediating Artifacts	Rules		Division of Labor	Community
	Classroom Tools	***Course Subject***	***National Culture***	***Group / Class setting***	***Socialization / Classroom Climate***
1	Advanced Programs / Software	Electro-magnetism	USA	3 groups of 3 per round table	Discourse stimulated technical, sensory, affective, & cognitive interactions
2	Advanced Programs / Software	Electro-magnetism	USA	3 groups of 3 per round table	Not within the research scope
3	Advanced Programs / Software	Physics	USA	2-4 students per group	Not within the research scope
4	Basic ICT	Biology & Finance	USA	Not specified	Students' suggested treatment promoted teamwork & collaboration
5	Advanced Programs / Software	Physics	China	3 groups of 3 per round table	Students' suggested treatment was more interactive and convenient for peer discussion
6	Advanced Programs / Software	Physics	China	Not specified	Students suggested treatment was more interactive and imposed greater pressure.
7	Basic ICT	Biology	USA	5-6 students per group	Observations showed significantly more group work and teacher-student consultations among the treatment.
8	Basic ICT	Biology	USA	3 groups of 3 per round table	Not within the research scope
9	Basic ICT	Biology	USA	3 groups of 3 per round table	Treatment space significantly influenced instructor behavior, classroom activities, and on-task behavior.
10	Basic ICT	Biology (non-majors)	USA	3 groups of 3 per round table	Classroom observations showed significantly more group work activity and teacher-student consultations among the treatment.
11	Basic ICT	Education (multiple disciplines)	Korea	5-6 students per round table; group size not specified	Treatment increased interest and participation and decreased positional discrimination.
12	Basic ICT	Chemistry	USA	350 seat lecture hall; or (3) 117 seat ALC	Not within the research scope

Park and Choi [11] provided a series of questions to assist directing future research emphasizing the institutional perspective of ALC implementation in higher education. The following questions were specifically proposed:

- What is the institution's vision for education and is it willing to deploy effective classroom space?
- Does the university and do its professors and students consent to experiencing a newly-designed classroom?
- Would the new space fit within the budget, coexist with the notion of providing enough classrooms, and blend naturally with the student population and culture? [11].

Additionally, [11] suggested that few research related to ALCs has been published within the context of Eastern national cultures. Given that these settings are often described being different from many Western educational contexts [24] and the only inconsistent cognitive learning outcome findings identified in this literature review were positioned among Eastern educational contexts [5-6], this is an issue worthy of future investigation. Park and Choi further elaborated the need to understand Korean and other Asian countries such as China, due to the cultural, historical, and religious differences. For instance, the notion that it is sometimes "considered rude for students in Korea, Japan, and China to ask questions, a function of educational practices with roots in Confucian doctrine" [11].

III. Conclusion

Based upon the evidence gathered in the present literature review, much research has supported understanding of ALCs at a broad level. However, the majority of research has examined STEM (science, technology, engineering, mathematics) disciplines and examined the in-class and out-of-class portions of the ALC as one environment, leaving some uncertainty regarding the influence and student perceptions of the two distinct educational components. Within the out-of-class component, in particular, research is needed to understand how students' social factors, such as student-to-student connectedness, may relate to students' acceptance of the technological systems. Additionally, the in-class component of ALCs require a deeper understanding of students' individual differences, such as their preferences for key learning environment features and relationships to perceptions of student-to-student connectedness.

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