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Exploring the Use of Clickers to Support Active Learning and Knowledge Building by Pre-Service Teachers in Large Lectures

by

Angyue Liu

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

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UNIVERSITY OF CALGARY

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled “Exploring the Use of Clickers to Support Active Learning and Knowledge Building by Pre-Service Teachers in Large Lectures” submitted by Angyue Liu in partial fulfillment of the requirements for the degree of Master of Arts in Graduate Division of Educational Research.

_____

Supervisor, Dr. Michele Jacobsen
Educational Technology
Faculty of Education

_____

Dr. Catherine Burwell
Educational Technology
Faculty of Education

_____

Dr. Brent Davis
Internal/External, Curriculum and Learning
Faculty of Education

_____

Date

ABSTRACT

Educators in higher education are being challenged to engage every learner in their learning in large lectures. This case study explored the use of an Audience Response System (i.e., clickers) to engage pre-service teachers in active learning and collaborative knowledge building in a large lecture setting within a Bachelor of Education program. Qualitative and quantitative data was collected from classroom observations, student interviews, the instructor interview, and the student survey. This research found that with the opportunity to respond to clicker questions in lectures, especially to the open-ended text-entry questions, student teachers can be engaged in active learning, and also in the creation, sharing, and promising improvement of their ideas/knowledge as individuals and as a learning community in the large lecture setting. Findings from this study can enrich our understanding about effective strategies of using clickers to improve learning and teaching in large lectures in higher education.

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DEDICATION

In Loving Memory of

My Grandma

Xujin Duan

A Dedicated Educator

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CHAPTER 1 INTRODUCTION

Today's undergraduates are primarily composed of the Net-Generation (i.e., people born between 1981 and 2001), a group that some argue actually learn in different ways than students from years ago. This argument can be supported by evidence that the majority of first-year undergraduates who were enrolled in Australian universities in 2006 had been found to be both familiar with technology and also reluctant to suffer passive learning environments (Murphy & Smark, 2006a; Murphy & Smark, 2006b). N-Gens are more oriented to active learning in a participatory culture facilitated by readily available online technologies (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006):

> A participatory culture is a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations…and a culture in which members believe their contributions matter, and feel some degree of social connection with one another (p.3).

Today's undergraduate students, who seem to be driven by active learning approaches and are experiencing technological interactions in many aspects of their daily life, provide grassroots motivation and pressure for faculty members to become more learner responsive in their instructional designs and course delivery methods, and in their use of technology-enabled approaches that may better support students in actively pursuing their learning goals.

Partly because of the large enrollments at many universities, large lectures have been found as a primary instructional approach used by instructors to share knowledge with a large group of undergraduate students. While large lectures are effective in some ways, such as presenting well-organized existing knowledge to a large group of students at the same time, Gremmels (1995) argues that large lectures fail to give every student an opportunity to practice any of the learned knowledge and skills, interact with their peers about concepts, and thus lead to passive learning

environments. A passive, large lecture delivery approach is contrary to N-Gens' needs and expectations for active learning and technology enhanced interaction and communication. Educators who endeavor to better engage N-Gens in active learning face the challenges of balancing between the learning and communication expectations of their students, the availability and adoption of learning technologies, and the proliferation of large lectures as a primary method of delivering undergraduate education.

Educational technology, which is defined as "the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources" (Januszewski & Molenda, 2008, p.1), has played an important role in revolutionizing learning and teaching approaches in undergraduate education, and has increasingly provided students with access to more active learning experiences in a participatory culture. "Would we not prefer an approach (assuming we could afford it) that exploits the pedagogical promise of emerging interactive technologies, and meets student expectations?" (Foreman, 2003, p.14). The purpose of this research study is to explore the use of an Audience Response System (i.e., clickers) to support and engage education undergraduates (i.e., pre-service teachers) to actively learn and to collaboratively build their knowledge in a large lecture setting.

Research Background

Considerable research has been done on studying the benefits of using clickers by undergraduate students in large-group learning environments (Beekes, 2006; Bruff, 2009; Cardwell, 2007; Fies & Marshall, 2008; Jefferson & Spiegel, 2009; Mollborn & Hoekstra, 2010; Patry, 2009; Stevenson, 2007; Trees & Jackson, 2007). Those perceived benefits of pedagogical use of clickers in large lectures in higher education include: real-time assessment of students'

understanding of course concepts, immediate feedback that informs students' and instructors' adaptable learning and teaching strategies, improved student's learning outcomes, promoted students' and instructors' satisfaction with a course, increased participation and student engagement, and so on.

Purpose of Current Study

This research study adds to the current knowledge base of clicker use in large undergraduate lectures in two ways.

First, relatively little of the research on clicker use has been conducted with pre-service teachers. Fies and Marshall (2008) did a study on the benefits of using clickers perceived by 161 pre-service teachers in a physical science course and by nine instructors. Instructors and student teachers reported higher levels of engagement when using clickers, especially when accompanied by peer discussion. More research is needed to explore clicker use by student teachers. The current study gauged student teachers' first-hand experiences on the benefits of using clickers in large lectures from their perspectives as undergraduate learners. More importantly, this study gained valuable suggestions on effective strategies towards instructional and technological use of clickers from student teachers' unique perspectives as future teachers who may implement clickers in their own teaching experiences.

Second, this study builds upon existing research on active learning with clickers in large undergraduate lectures, by studying *attention, participation, instant feedback, interaction, reflection* on learning. More importantly, this study crosses a research boundary to explore how the use of clickers may support instructors in creating higher-levels of active learning, such as *knowledge building* (Scardamalia & Bereiter, 2010).

The twenty-first century is a world dominated by constant changes, a technique mastered or a theory learned today may need to be updated tomorrow. Thus, building new ideas/knowledge is the lifeblood of people who are competing to survive and prosper in a rapidly changing and expanding world. To embrace rapid changes in the 21st century, the ultimate objective of education needs to be shifted from developing knowledge recipients to nurturing knowledge builders who are engaged in collaborative knowledge creation and idea improvement to keep themselves updated in the changing knowledge world. Educational technology can contribute to creating knowledge building environments for learners. For example, Blog – a web communication platform, has been used to facilitate both personal and collective learning in a way that the published personal thoughts can shape or be shaped by others' thoughts that have similar interests in collective conversations through having access to authors' original posts, readers' comments and links to other web pages (Thomas & Brown, 2011).

This study intends to explore the following questions: how can the use of clickers serve the educational objectives of engaging students in large undergraduate lectures to create new ideas/knowledge, to share those individual ideas/knowledge with peer students, and to collaboratively improve those ideas/knowledge as a learning community where every learner can take part in and be proud of making contributions to individual and the community's learning? Findings from this study can be used to address the knowledge gap of using clickers to facilitate student teacher's deep learning in higher education.

Research Question

During the Winter 2012 semester, this study was carried out in a lecture series with 375 pre-service teachers, within the Bachelor of Education program at the University of Calgary. The study aimed to address three research questions:

1) In what ways and to what extent does the use of clickers in large undergraduate lectures engage pre-service teachers in active learning?
2) In what ways and to what extent does the use of clickers in large undergraduate lectures engage pre-service teachers in knowledge building?
3) What are some of the effective instructional strategies regarding clicker use that can better engage students in active learning and knowledge building in large undergraduate lectures?

Significance

It is anticipated that findings from this study can enrich our understanding about active learning and knowledge building with the use of clickers in large undergraduate lectures, and can inform and direct future learning, teaching, and research practices regarding clicker use. One goal of this study is to encourage higher education faculty to consider implementing clicker technology across disciplines for quality learning and teaching. This study also has a significant value to the unique research participants, the pre-service teachers, because this population crosses a boundary between learning as learners and also learning as prospective teachers.

Pre-service teachers are the power and future of education. The effectiveness and success of an educational shift in schools from information delivery to engagement in various learning activities, and to the collective knowledge building depends, in part, on the new generation of teachers who graduate from Faculties of Education and take their places as classroom teachers. Pre-service teachers need to be engaged in the types of learning experiences they are expected to create for their own students (Jacobsen, 2010) – in this case, learning experiences that engage student teachers in active learning and knowledge building. By educating the new generation of

teachers in innovative learning approaches, it is hoped that they will provide similar learning experiences for their own students, the Millennials, who were born between 2000-2020, and will develop knowledge builders who are more competent to embrace the world of constant changes.

CHAPTER 2: LITERATURE REVIEW

This chapter is a review of historical and current research on why educators choose to implement an active learning technique, Audience Response Systems (ARS), into large lectures and how ARS has contributed to promoting active learning in large lectures. Through this literature review, gaps in the current knowledge base are highlighted, the idea of using ARS to support knowledge building in large lectures is introduced, and research questions that frame this study are generated.

The review of literature summarizes that considerable research has been done to understand the benefits of using clickers to support active learning in large undergraduate lectures, especially in business, and natural science disciplines, such as chemistry, computer science, nursing and physics. As Jacobsen and Davis (2011) and Jacobsen, Reid, Liu and Rajasekaran (2011) argue that relatively little research on clickers has been conducted with education undergraduate students (i.e., pre-service teachers), there exists an opportunity to build upon prior studies and to explore the ways and extent to which the use of clickers supports active learning and knowledge building by pre-service teachers in large lectures, from their perspectives as both learners and prospective teachers.

Audience Response Systems

The Audience Response System (ARS) is a computer-based system involving a handheld keypad called a clicker that allows students to anonymously respond to questions prepared by the instructor, an infrared or radio frequency receiver that picks up the signal transmitted by the clicker, and software installed on a computer to process the information collected by the receiver and immediately display the aggregate responses to students in graphical or textual formats. Based on the student responses, the instructor can adapt the flow of the class to cover materials

that may not have been correctly interpreted or widely understood, to structure peer, group or full class discussion. The ARS offers a powerful and flexible tool for enhancing teaching and learning in multiple disciplines at a variety of academic settings ranging from K-12 schools to post-secondary institutes (Caldwell, 2007). The ARS is increasingly being used in classrooms, especially in large lectures in higher education to provide immediate feedback to students, enhance student-student interaction and student-teacher interaction, motivate and engage students, increase students' achievement, and add varieties to a dynamic learning environment. Given the breadth of terminology used to describe an ARS, this literature review includes research findings using a range of related terms such as clickers, Personal Response Systems (PRS), Classroom Response Systems (CRS), Student Response Systems (SRS), Student Response Technology (SRT).

ARS and Active Learning

Definitions of Active Learning

To better understand the effects of an audience response system on student active learning, it is necessary to understand how active learning is defined. Active learning is not a new concept and was listed by Chickering and Gamson (1987) as one of the seven principles to evaluate good practice in higher education. Hall, Waitz, Brodeur, Soderholm, & Nasr (2002) defined active learning as a teaching technique that addresses students' active involvement in their own learning. Smith and Cardaciotto (2011) argued that in contrast to passive learning where the responsibility of designing and delivering instruction completely falls on the teacher, active learning is a student-centered inductive learning process. Michael (2006) offers a thorough interpretation of active learning as:

> The process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas. Requiring students to regularly assess their own degree of understanding and skill at handling concepts or problems in a particular discipline. The attainment of knowledge by participating or contributing. The process of keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving (p.160).

And an active learning environment can be exemplified by the following characteristics (Bonwell & Eison, 1991; Chickering & Ehrmann, 1996):

- More student-teacher interactions;
- More student-student interactions;
- Students are engaged in activities;
- Students are focused more on developing skills as opposed to memorizing facts;
- Students are more motivated to learn;
- Students receive immediate feedback from their instructor;
- Students are involved in higher-order thinking (Anderson & Krathwohl, 2001), such as analysis, evaluation, and creation.

In addition, Hall et al. (2002) argued that the benefits of active learning include developing students' abilities in communication, leadership, decision making and critical thinking.

Passive Lecture Environments

The traditional lecture has been the reservoir of facts, on an assumption that comprehensive and organized coverage of facts is the main objective of a lecture (Stevenson, 2007). Stevenson (2007) further claims that a lecture that only duplicates pre-existing materials is not worth the

time. Students in traditional lectures are usually found to skip classes without detection, sit quietly in the back of the room, and refrain from answering questions or participating in discussion (Trees & Jackson, 2007). These passive learning objectives and behaviors are not effective and successful learning approaches for students. Large class sizes, usually ranging from 50 to 300 students, create ongoing challenges for instructors who aim to, or attempt to engage students in active learning (Brooke, 2009; Cox & Rogers, 2005; Nagy-Shadman & Desrochers, 2008; Sprague & Dahl, 2010). Cox and Rogers (2005) blame the traditional lecture for not actively involving students and call for a well-designed lecture in which technology-based teaching and learning tools can be used to support an active and learner-centered lecture environment.

ARS and Active Lecture Environments

A large number of studies (Albon & Jewels, 2007; Hoekstra, 2008; Martyn, 2007; Mollborn and Hoekstra, 2010; Murphy & Smark, 2006b; Nagy-Shadman & Desrochers, 2008; Patry, 2009) have found ARS to be an effective and successful tool to help implement active learning in large lectures. Patry (2009) argues that the implementation of ARS can increase active participation in educational settings, such as large lectures, that have traditionally limited students' involvement to more passive roles. Hoekstra (2008) found that in large lectures of General Chemistry, the use of clickers could provide students with a perceptual ‘break’ from passive note-taker roles to active information processors, and could generate discussions or any other learning activities that would alleviate the boredom (or passivity) commonly felt in large traditional lectures. Students interviewees in Mollborn and Hoekstra (2010)’s study also believed that clicker use could help foster a more active learning environment in large lectures, mainly

because with the clicker use, more bodies are present, more voices are being heard, and students have more interaction with each other.

According to the characteristics of active learning environments, the following sections elaborate on how the clicker use contributes to establishing an active learning environment by: 1) increasing students' participation and contribution; 2) providing students with instant feedback, which gives students opportunities to conduct self-assessment of their learning; 3) enhancing student-student and student-teacher interaction; 4) engaging students in their learning; 5) promoting students' motivation of learning; 6) involving students in higher-order thinking.

Participation

The use of clickers can greatly increase student participation levels in large classes (Kaleta & Joosten, 2007; Mula & Kavanagh, 2009). As part of the Dynamic Education project conducted in an Australian university in evaluating the benefits of using education technologies in teaching and learning (Mula & Kavanagh, 2009), the Student Response System (SRS) was used in a first-year accounting course offered in three semesters. Sixty-one students enrolled in semester 2 used SRS. As a control, 33 and 26 students in semesters 1 and 3 did not use SRS. Student responses to class quizzes and course evaluation questions showed that students were more willing to provide a more complete answer to questions when clickers were being used than not. The anonymity of clickers is found as an element contributing to the increased participation (DeBourgh, 2008, Martyn, 2007). Martyn (2007) investigated students' perceptions of learning with two different active learning techniques in an Introductory Computer Information Systems class at an American college. One group with forty-seven students had class discussions in a traditional way, while the other group with forty-five students used clickers in their discussion. The only difference between the two groups was that "the students using class discussion needed to raise

their hands to respond, so their responses are not anonymous" (p.73). Survey results showed that student participation in the group with the use of anonymous clickers was significantly higher than the other group. Besides the evidence of student's higher participation in responding to clicker questions, half of the participants in Nagy-Shadman and Desrochers (2008)'s research agreed that the Student Response System (SRT) increased their willingness to ask questions in class. So, from the research it is clear that clickers can be used to increase participation and discussion in large lectures. Students appreciate and value the opportunity to contribute responses anonymously, and they are more likely to ask questions using the clickers.

Instant Feedback and Self-Assessment

Clicker technology is often used as a formative assessment tool, usually in the form of short quizzes, to provide students an opportunity to self-assess their learning (Hoekstra, 2008; Johnson & Lillis, 2012; Murphy & Smark, 2006a; Sprague & Dahl, 2010). Johnson and Lillis (2010) presented the perceptions of Irish Nursing students with regard to the use of clickers in the clinical skills laboratory. 120 students had a clicker based quiz in relation to wound care and management. After the quiz, students were asked to fill in an anonymous questionnaire to share their experiences with using clickers. Responses to the questionnaire indicated that both the students and the instructor benefited from the immediate feedback regarding students' conceptual understanding of wound care and management.

In Sprague and Dahl (2010)'s research, the instructor in an Introductory Marketing course at a large Canadian university used Personal Response System (PRS) to administer regular class quizzes. The instructor claimed that having the correct answer to each quiz question display instantaneously could conserve lecture time. Students profited by the regular clicker based quizzes, as both an encouragement to remain current in their course work and as a signal of exam

expectations. Hoekstra (2008) articulated that one of the reasons that students feel more active with the use of clickers is that they can immediately apply the knowledge learned during lecture time, instead of waiting for the exam to do so. Murphy and Smark (2006a) summarized the benefits of having instant feedback generated from the Personal Response System (PRS) as: from students' perceptions, it could help them assess individual learning progress; from instructors' views, it could help them gauge where the class is currently positioned in terms of knowledge base, and help them make decisions on whether more instruction is needed on a particular concept or skill (Murphy & Smark, 2006b; Sprague & Dahl, 2010); from the university's perspective, it could be proactive towards remedial actions to student learning difficulties, and could be a documentation of students' work effort.

Interaction

As an active learning technique, the use of clickers can greatly enhance student interaction with peer students and with the instructor (Johnson & Lillis, 2010; Kaleta & Joosten, 2007; Martyn 2007; Nagy-Shadman & Desrochers, 2008). Sprague and Dahl (2010) demonstrate that because of the perceived benefits of increasing interactivity within a large group, clicker technology is primarily implemented in large classes, ranging from 50 to 300 students. In 2006, Kutztown University began a project selecting a standard clicker system to use in multi-disciplines (Jefferson & Spiegel, 2009). The project was initiated because students were frustrated by the incompatible clicker systems being used in different programs across campus. During the project, a survey was administered to 145 students at the Chemistry Department, and the responses indicated that about 73% of the students agreed or strongly agreed that the clicker use improved classroom interaction. In addition, an instrument had been developed by Siau, Sheng, and Nah (2006) to evaluate the effects of using ARS on students' interactivity in

traditional undergraduate and graduate lectures. The instrument containing 10 Likert-scale questions was administered using a pre/post test approach. Siau, Sheng, and Nah (2006) found that “descriptive statistics indicated that student’s level of interactivity was increased after using the classroom response system” (p. 400). Furthermore, the sort of instant feedback of student responses to clicker questions helps students “use interactivity in the context of discussing their selected answers with their neighbors who chose differently, and also comparing individual opinion with those of the whole class (Murphy & Smark, 2006b, p.7). Murphy and Smark (2006b) reported that the PRS technology also gives students an opportunity to build knowledge through interconnections “by allowing students to have their initial thoughts recorded and then to discuss with their peers and change their answers where necessary” (p.7). Evidence from research reviewed thus far shows that clicker use can increase student’s interactivity in large lectures where students are given a chance to discuss their opinions and improve their understanding.

Engagement

Generally speaking, clickers can be used as a “game approach” that actively engages students in lectures, by posing clicker questions at pedagogically strategic moments (Kaleta & Joosten, 2007; Martyn, 2007). In 2005, the University of Wisconsin did a systematic, large-scale study across its four campuses, examining perceptions and attitudes regarding clicker use by 27 faculty members and 2684 students from 19 disciplines in classes of different sizes (Kaleta & Joosten, 2007). The survey data showed that 94% of the faculty respondents agreed or strongly agreed that there was greater student engagement in class as a result of clicker use, and 69% of student participants agreed or strongly agreed that the use of clickers made them feel more engaged in class.

Nagy-Shadman and Desrochers (2008) surveyed three student groups to research whether the Student Response Technology (SRT) helped increase student engagement. The three groups are: 1) clicker group composed of 350 students enrolled in 13 earth and physical courses at California State University, Northbridge (CSUN), 2) randomly selected students from CSUN, 3) students from comparable colleges and universities. In this study National Survey of Student Engagement (NSSE, 2004) was used as the protocol to survey the level of student engagement. Responses showed that students in the clicker group had a higher level of academic and intellectual engagement than the other two groups. Evidence of student engagement included, "asked questions in class or contributed to class discussions", "worked harder than you thought you could to meet the instructor's standards or expectations" (p. 2034). Responses from several large-scale survey studies report that student engagement in their learning can be increased with clicker use, either in large lectures or in small classes.

Motivation

Students tend to show greater motivation when learning with clickers in classes (Johnson & Lillis, 2010). Some instructors have found that one way to promote motivation in learning is to give students bonus points based on the percentage of correct responses as an incentive. In Cain, Black, & Rohr (2009)'s research, students can receive bonus points provided that 80% of the class answered a question correctly. Albon and Jewels (2007) conducted a research to understand the perceived effectiveness of ARS technology by the multicultural Asian staff and student populations at an Australian offshore university campus located in Malaysia. One hundred and thirty-three students and four lecturers participated in this project, and most of the participants were ESL speakers. The majority of student participants believed that they were definitely or somewhat motivated to participate in class, and they regarded ARS as a motivator in their

learning. But Nagy-Shadman and Desrochers (2008) found that only 30% students felt that the use of SRT increased their desire to come to class to learn, while a significant number of students chose 'neutral' (47%) or disagreed (23%) towards this point. Nelson and Hauck (2008) found that the greater the volume of clicker usage was, the more favorable student perceptions were in terms of motivation. This implies that the level of student motivation partially depends on how the instructor uses clickers. So, the research reviewed here appears to show that students' motivation can be promoted with clickers, but the level of motivation varies in different learning contexts.

Higher-Order Thinking

There was limited research found that demonstrates that clickers have the potential to develop students' higher-order thinking skills, such as application, problem-solving, critical thinking. In DeBourgh (2008)'s study, application-style clicker questions that requested students to determine priorities of patient care management were asked in a 15-week advanced nursing therapeutics course. Of the 65 students who completed an anonymous satisfaction survey in the 14th week, 64% thought that they did more thinking during clicker session than in regular lecture session, and 82% agreed or strongly agreed that using clickers in class helped them develop advanced clinical reasoning skills. Drawing upon students' narrative comments, DeBourgh (2008) reported that students were found more aware of their thinking abilities and were more skilled at carrying out various approaches to solve complex problems with clicker use. These findings are consistent with Russell, McWilliams, Chasen, & Farley (2011)'s findings, which indicate that clicker questions can be used to develop critical thinking skills of the second-degree nursing students in large lecture-based classes, and help them synthesize newly gained professional knowledge. However, Nagy-Shadman and Desrochers (2008) found that only 42%

of the 350 students enrolled in earth and physical science courses agreed that Student Response Technology (SRT) contributed to improving their problem-solving skills. Evidence has been found shows that student's higher-order thinking skills can be developed, but the level of which also varies in different learning contexts.

This review of literature indicates that among those active learning characteristics that clickers managed to support, more research has been done on, *participation*, *instant feedback and self-assessment*, *interaction*, *engagement*, and *motivation*, and relatively little research has been done on *higher-order thinking*, such as knowledge building.

ARS and Knowledge Building

Definition of Knowledge Building

Bereiter and Scardamalia (1989) originally introduced the term "knowledge building" (p.388) into education research. However, the term "knowledge building" has not been universally defined. Knowledge building can be referred to as collaborative creation and continual improvement of knowledge that has value to the whole community (Scardamalia & Bereiter, 2010). The community knowledge does not just reside in the minds of individuals but is available for others to build on and improve (Scardamalia et al., 2012). Knowledge building is a kind of deep constructivism, leading to the emergence of new ideas and continued efforts to improve ideas (Scardamalia & Bereiter, 2003). Three key words are generated from the definition of knowledge building, which are *creation*, *sharing*, and *improvement*.

Active Learning and Knowledge Building

Active learning is the entry level of knowledge building environments, while the complex systems of interactivity and knowledge work that enables the generation of new knowledge, the capacity to exceed standards, and the drive to go beyond best practice at the high end are the

characteristics of higher level of the knowledge building environment (Scardamalia et al., 2012). Constructivist learning theory necessitates that the learners be problem solvers and active participants in the learning process (Trees & Jackson, 2007). Knowledge building, the creation of knowledge, is defined as a higher level of learning and thinking, and bears some relation to the constructivist learning theory (Scardamalia, 2002; Scardamalia & Bereiter, 2010). In order to create a successful knowledge building environment, students should be first engaged in learning activities where active learning functions as a foundation and requisite of developing higher-level thinking skills, collaboratively creating and improving knowledge.

Knowledge Building Principles

Scardamalia (2002) designed twelve *"knowledge building principles"*, which draw a complete picture of knowledge building. The twelve principles can be used to evaluate the level and quality of knowledge building in classrooms, and to evaluate the effectiveness and efficiency of educational technologies (e.g., Knowledge Forum) that are used to support knowledge building. Scardamalia and Bereiter (2010) elaborate on the twelve principles as:

Real ideas, authentic problems: "Knowledge problems arise from efforts to understand the world. Ideas produced or appropriated are as real as things touched and felt" (p.9).

Improvable ideas: "All ideas are improvable. The space for idea improvement must be one of psychological safety, so that people feel safe in taking risks – revealing ignorance, advancing ill-conceived or half-baked notions, giving and receiving criticism" (p.9).

Idea diversity: "Ideas are improved through comparison, combination and alignment with other ideas. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it" (p.9).

Rise above: Knowledge builders move beyond current practices, work with diversity, complexity and messiness to achieve inclusive and higher-order understanding.

Epistemic agency: "Individually, knowledge builders set forth their ideas and negotiate a fit between personal ideas and ideas of others, using contrasts to spark and sustain knowledge advancement. Collectively they deal with problems of goals, motivation, evaluation, and long-range planning" (p.10).

Community knowledge: Contributions to the shared knowledge of a community are as important as individual achievements.

Democratizing knowledge: "All participants are legitimate contributors to the shared goals of the community; all take pride in knowledge advances achieved by the group; all are empowered to engage in knowledge innovation" (p.10).

Symmetric knowledge advancement: Knowledge does not only move from the more knowledgeable to the less knowledgeable group. Knowledge is distributed among members of the community.

Pervasive knowledge building: "Knowledge building is not confined to particular occasions or subjects but pervades all tasks and activities of knowledge work" (p.10).

Constructive uses of authoritative sources: To know a discipline is to respect and understand the authoritative sources that mark the current stage of knowledge and its frontiers, combined with a critical stance toward them.

Knowledge building discourse: The knowledge itself is shared, refined, transformed and advanced through the discursive practices of the community.

Concurrent, embedded, and transformative assessment: "Assessment is part of the effort to advance knowledge – it is used to identify problems as the work proceeds and is embedded in the day-to-day workings of the organization" (pp.10-11).

This section gives a brief interpretation of knowledge building. The next section maps between the knowledge building theory and the pedagogical use of clicker technology, and seeks the potential of using clickers to support knowledge building in large lectures.

ARS Pedagogy and Knowledge Building

Effective pedagogy and successful student learning are priorities when designing and delivering technology-enabled instruction. The following sections introduce effective pedagogies that can maximize the potential of using clickers to support knowledge building.

Clicker Questions

"Learning beyond the mere recall of facts requires innovation and non-traditional instructional strategies" (Skinner, 2009, p.20). An instructional approach that utilizes questions and student responses as the basis for classroom learning is referred to as "question-driven instruction" (Beatty, Gerace, Leonard, & Dufresne, 2006). The question-driven approach to promoting interaction combined with effective question design can improve learning beyond simple memorization of facts to the building of knowledge.

In his book on creating active learning environments using audience response systems, Derek Bruff (2009) advocates that instructors use clicker questions to engage students in active learning, to collect and analyze data on student thinking, and to adjust their instruction accordingly. Bruff (2009) argues that the effectiveness of the use of ARS depends heavily on the quality of clicker questions, and identified several different question types that target particular pedagogical purposes:

- Recall questions: Emphasis on understanding existing information and content, used to support students in remembering facts, concepts, or procedures relevant to the discipline under study.
- Conceptual understanding questions: Emphasis on conceptual knowledge, used to support students in recalling and recognizing course content, and further, for students to understand the concepts associated with a topic and application of the concept in practice.
- Application questions: Emphasis is similar to procedural knowledge questions, and emphasizes integration and connections among ideas; requires students to remember and understand various issues and topics, and to apply their understanding to various cases and scenarios.
- Critical thinking questions: Emphasis is on metacognitive engagement, analysis of data and contexts, and evaluation of scenarios, situations; requires students to analyze relationship among multiple concepts or make evaluations based on particular criteria.

Different question types tend to occupy a continuum from questions that emphasize and support lower-level thinking to those that require higher-level thinking and reflect the Cognitive Process Dimension (Anderson & Krathwohl, 2001), which evolves from *remember*, *understand*, *apply*, *analyze*, to *evaluate* and *create*. Learning objectives classified as *create* have students build a new knowledge outcome by mentally reorganizing some elements or ideas into a new pattern or structure not clearly present before (Anderson & Krathwohl, 2001). Knowledge building, as defined by Scardamalia and Bereiter (2010), can be understood as public and collaborative engagement in knowledge creation and idea improvement, and can be classified as questioning at

the critical thinking and *create* levels, which require students to engage in and to master higher-level thinking skills.

"Learning objectives serve as a framework for the development of questions and the implementation of instructional strategies" (Skinner, 2009, p.21). Skinner (2009) emphasizes that the creation of clicker questions needs to be guided by what learning outcomes the instructor wants students to achieve, and what kind of thinking skills the instructor wants students to master, develop and apply. Every clicker question should serve an explicit learning objective, such as content goal, process goal, metacognitive goal, and so on (Beatty et al., 2006; Caldwell, 2007). Therefore, if the goal is to facilitate knowledge building in large lecture settings, then the instructor needs to design clicker questions according to the principles of knowledge building (Scardamalia & Bereiter, 2010), which are:

- *Real ideas and authentic problems*: High quality questions that support and require students to make connections between their own understandings and real-world experiences and disciplinary knowledge (Walsh & Sattes, 2005).
- *Improvable ideas*: Quality knowledge building questions provoke students to think deeply about ideas and generate responses that help individuals and the group to improve upon these ideas; quality questions also support students in understanding that good ideas are improvable, and that there are gradations and levels of correctness that are more nuanced than "right or wrong".
- *Idea diversity*: Questions that promote greater understanding of idea diversity are designed to collect and analyze a spectrum of responses, focus on issues and unresolved conflicts, and engage students in thinking beyond their own position and beliefs to consider other perspectives and positionalities.

- *Constructive use of authoritative sources*: Questions require students to engage with and develop an understanding of authoritative sources, to construct meaning from pre-existing knowledge and sources (National Research Council, 2000), and to use this knowledge to develop a critical stance, to defend a position, to develop research informed dispositions toward those authoritative sources.

Further, knowledge building questions must guide students' study away from rote memorization, and should contain uncertainty, controversy, analysis or application of learning materials to best provoke and stimulate student's thinking (Stevenson, 2007). Overall, an instructor whose goal is to use ARS questioning strategies in large lectures to increase students' engagement in higher-level thinking must use rich and engaging questioning practices on a regular basis (Shirley, 2009). In conclusion, to make the most effective use of clickers for higher-order thinking, Bruff (2009) and others argue that instructors should design questions that engage students in building and creating new knowledge and understandings.

However, it needs to be acknowledged that knowledge building is a disposition and type of engagement that can be challenging for instructors to develop and assess through the closed or multiple-choice clicker questions alone (i.e., responses that are just a few words, yes/no, or true/false); while the open-ended, text-entry questions may be more useful for assessing students' ability to create, generate, or produce new knowledge or understanding. When learners respond to the open-ended questions, they can provide their thoughts and ideas more creatively without constraints (Bruff, 2009; Carr, 1998; Chin, 2004). Mollborn and Hoekstra (2010) found out that the close-ended clicker questions used in a sociology course resulted in a learning environment where students felt examination oriented and merely focused on getting the correct

answer, rather than cooperatively exploring new knowledge and understanding. Korkmaz (2009) notes that teachers commonly pose multiple-choice questions with a single correct answer. This practice is determined to be contradictory to the development of higher-level cognitive skills such as *analysis, evaluation* and *creation*, and to the practice of knowledge building.

Furthermore, clicker questions should be carefully constructed to lead to cognitively high levels of discussion (Skinner, 2009) in a purposefully designed and supported knowledge building community. As EDUCAUSE (2004) elucidates, the real strength of an ARS is not just a way of asking questions, re-asking them, or inserting audience questions into a teaching situation. To maximize the potential for the ARS is to fully engage students in refining and extending their understanding of the material with activities and discussion.

Discussion

Clickers can be used to promote discussion in large lectures. Groups tend to solve problems better than even the brightest individuals do alone. This is especially true when the groups are diverse and individuals act somewhat independently (Herreid, 2009).

To cultivate a knowledge building culture, the instructor needs to pair well-written, open-ended questions with time for small group or class-wide discussion either before or after students input their responses or the response patterns are revealed.

Beekes (2006) states that clicker use offers many ways to stimulate discussion because they encourage learners to express their opinions and give them access to group response trends and peer thinking. Beatty et al. (2006) describe the discussion that accompanies use of question-driven instruction as a valued learning opportunity for students to confront different perceptions, different approaches to analysis and different conclusions. Beatty et al. (2006) also argue that

exposing students to their peers' thinking often challenges the individual's thinking and promotes better learning.

Discussion is not directly embedded in the ARS; however, discussion can and should be facilitated by the instructor through the pedagogical use of ARS. Dufresne, Gerace, Leonard, Mestre, & Wenk (1996) employed a "class-wide discussion" format in conjunction with clickers. First, students submitted their answers individually. Then, a histogram of answers was presented to students. Without giving away the correct answer instantly, the instructor encouraged and facilitated a class-wide discussion during which students provided an argument for their response, asked questions, or added information. Finally, the instructor provided the correct answer along with an explanation for it, which led to further discussion among students.

The histogram of responses plays an important role in leading to students' deeper thinking and sparking subsequent discussion. Mollborn and Hoekstra (2010) believe that viewing the histogram of responses facilitates creating a critical thinking "space" for students to examine the responses they have chosen and to reflect on peer's responses that reveal similarities and diversities. Students feel that they are not alone in their choices through viewing the histogram, especially when there is no one predominant answer, thus students have more courage and confidence to speak up in their own defense (Fies & Marshall, 2008).

Marlow, Wash, Chapman, & Dale (2009) address that designing and asking sound questions is crucial both to eliciting participation and to initiating successful discussions. Although the histogram of response to close-ended or multiple-choice questions can spark student's critical thinking, opinion questions without a correct answer were found to be more effective in prompting discussions about the breakdown of opinions, beliefs and values that exist in a learning community (Mollborn & Hoekstra, 2010). In knowledge building classrooms,

cognitively high levels of discussions are necessary and important to generate diverse ideas and promote idea improvement. The following principles of knowledge building theory (Scardamalia & Bereiter, 2010) offer instructors ideas toward designing clicker questions and participatory pedagogies that facilitate cognitively high levels of discussion:

- *Rise above*: Strong questions require students to work with diversity, complexity and messiness in the discipline of study. Emphasis is on students achieving new syntheses through comparison, combination and alignment during discussion.
- *Epistemic agency*: Great questions allow students to assess their epistemic awareness (what and how you know, what you do not know and need to learn) in a collective way (listening to peer classmates).
- *Knowledge building discourse*: Strong questions and participatory pedagogies facilitate peer-to-peer discourse which can collaboratively advance and improve upon accepted ideas.

In conclusion, Fies and Marshall (2008) state that the use of ARS in a discussion-based learning environment facilitates student participation, invokes deeper thinking and increases perceptions of personal relevance and agency. Discussion is a valued opportunity for students to develop and work out ideas, promoting the development of a learning community (Fredricksen & Ames, 2009; Wang & Keogh, 2010). So, while the design of good quality clicker questions is essential to effective learning, the type and style of instruction and peer interaction that is supported in the learning environment is also an essential condition to optimal clicker use.

Anonymity

One of the strengths of ARS is the possibility for students to input responses anonymously. Most ARS systems give instructors the choice to use the system for anonymous input, and student data cannot be linked with their identity. Instructors can also use the ARS with a login procedure that records attendance, participation and response data for each student; instructors often use the login feature when the ARS is used for exams or tests.

Still, audience response pedagogy can be done without technology. For example, an instructor can poll the class, and ask them to raise their hands or flash a colored or coded response card, or give verbal responses. Drawbacks to this approach include having the whole class readily see how other students have responded; also, the instructor does not have an accurate record of the group responses – once the hands go down, the data is lost. In Stowell and Nelson (2007)'s study, one hundred forty undergraduate students enrolled in introductory psychology classes were assigned into three groups. The three groups of students responded to questions asked in classes by raising their hands, using response cards and clickers respectively. The results showed that participation was the highest in the clicker group, followed by the response card group and the hand-raising group. Stowell and Nelson (2007) also found that the use of clickers could increase the honesty of student response, while both the response card group and hand-raising group were susceptible to the influence of social conformity because students might wait and respond to questions after other students responded.

A problem that can be overcome using an ARS anonymously is the student who resists sharing their insights, knowledge and experience with the group due to feelings of inadequacy or insufficient knowledge or experience (Gentry, 2009), or the feel of giving a public response. One hundred and forty-three respondents from 161 pre-service teachers stated that they felt they

could safely participate during an anonymous input collection and that the feedback in form of a histogram further supported safe and valid participation within a community (Fies & Marshall, 2008). According to the knowledge building principle of *improvable ideas* (Scardamalia & Bereiter, 2010), the anonymous ARS technology can provide such a safe environment for students to offer new ideas and improving ideas. Most students' and teachers' comments indicated satisfaction in the first-year accounting courses expressed satisfaction in the more egalitarian environment offered by the use of anonymous clickers, which encourages and allows all students to have an equal voice (Mula & Kavanagh, 2009). Mollborn and Hoekstra (2010) also report that using clickers with effective pedagogy can foster students' feelings of solidarity in a learning community and turn isolated large classes into "meetings of minds", not just one mind. According to the knowledge building principles, *democratizing knowledge* and *symmetric knowledge advancement*, a knowledge building environment that recognizes and honors the contribution of all students can be developed in conjunction with the use ARS.

Knowledge Gap

Dangel and Wang (2008) point out that there is an increase in the number of investigations that are designed and conducted to gauge the benefits of using ARS to address deep learning versus surface learning concerns, but that limited evidence is found on using ARS to enhance student learning in one domain of Cognitive Process Dimension (Anderson & Krathwohl, 2001), which is *creation*. Dangel and Wang (2008) articulate that "students need an SRS technology that would afford them the tools to generate responses rather than just recognize response options" (p.97), which points out a direction to question whether the clicker technology can actively engage pre-service teachers in collaboratively creating, sharing, and improving their ideas and knowledge in a learning community.

Conclusion

In this chapter, previous research on promoting active learning in large undergraduate lectures by using clickers is summarized, and the potential relationships between knowledge building and pedagogical use of clickers is mapped out. Chapter Three details how this research study was designed and carried out in order to address the knowledge gaps identified in the literature review.

CHAPTER 3 RESEARCH METHODOLOGY

Using a case study approach, this research builds upon what is known about using clickers for active learning in higher education by studying the use of clickers with undergraduate education students. There are three research questions that frame this study:

1) In what ways and to what extent does the use of clickers in large undergraduate lectures engage pre-service teachers in active learning?
2) In what ways and to what extent does the use of clickers in large undergraduate lectures engage pre-service teachers in knowledge building?
3) What are some of the effective instructional strategies regarding clicker use that can better engage students in active learning and knowledge building in large undergraduate lectures?

Research Design

A case study methodology using mixed methods (i.e., qualitative and quantitative) of data collection and analysis has been employed for this study. The distinct need for case study arises out of the desire to have a holistic and deep understanding of real-world contexts, and to produce a new meaning of the real-world contexts, such as group behaviors and school experiences (Yin, 2009; Yin, 2012). This case study intended to gain an in-depth understanding of how the clicker technology could support a large group of students to actively learn in large lecture settings. This case study also aimed to explore an unknown world of how clickers could support student teachers to collaboratively build their knowledge both as learners and as prospective teachers. Finally, this study aimed to develop better understanding of effective instructional strategies regarding clicker use in undergraduate education.

Case study research methodology has its distinct advantage in situations where the researcher aims to answer research questions that are asking "*how*" or "*why*" about certain contexts within which the researcher has little or no control (Yin, 2009). This case study gathered students' direct experiences of *how* the clicker use supported their active and deep learning in a large lecture setting without imposing any control or treatment variables. This study happened in the natural conditions of an undergraduate lecture at a research intensive university.

In addition, as Yin (2009) indicated, a major reason for conducting a single-case study is that the single case is a representative or typical case from which the findings can be informative about the experiences of the average group. This case study was conducted in a lecture series within a Bachelor of Education program which is a representative case that can inform our understanding about pre-service teachers' average experience on clicker use in large lectures.

Qualitative and quantitative data were collected and analyzed in this case study research. The strength of a mixed methods study is that it combines the advantages of each form of data, that is, qualitative data from interviews with participants and observations in the field offers in-depth information about contexts and settings, whereas quantitative data from surveys can provide more generalizability (Creswell, 2012). "Case study research is not limited to a single source of data…In fact, good case studies benefit from having multiple sources of evidence" (Yin, 2012, p.10). In this research, multiple sources of evidence were gathered from classroom observations, student interviews, instructor interview, student survey, clicker questions and student responses, in order to construct a more triangulated understanding of learner and teacher experiences with clickers and to make knowledge claims in response to the research questions in this case study.

Research and Learning Context

In the Winter 2012 semester, the researcher studied the use of clickers with 375 pre-service teachers in a second-semester teacher education course in the Bachelor of Education program at the University of Calgary. This course component included large plenary sessions and small seminars. The clicker research was conducted only in the plenary sessions of the course, not in the small seminars. There were ten plenary sessions during the whole semester. Each plenary lasted for one hour and fifteen minutes and was scheduled in the evening from 5:30pm to 6:45pm starting January and running until March. The plenary was offered in a large lecture hall that contains 413 seats. The overall learning goal of the plenary was to foster understanding and responsibility of continued professional development and lifelong learning within teaching practice. The plenary created a space for student teachers to reflect on significant learning moments and experiences that have contributed to arriving at this place and time in their own learning journey and on the important work they do as teachers and educators.

In this investigation, SMART Technology's SMART Response XE system with two receivers and SMART Notebook software were installed on a computer, and 200 SMART XE hand-held mobile devices (i.e., clickers) were available to be used by the students and instructor.

The response system was used in seven of the ten plenary sessions starting from the second plenary. For each plenary, the instructor typically prepared one or two clicker questions endeavoring to engage students in their learning. The majority of the clicker questions were open-response text-entry questions that allow for up to 140 characters in response, and a few of the questions were multiple-choice questions. Before each plenary, the instructor created the questions, saved it as a Word document and sent a copy to the researcher and a teaching assistant to put it in a SMART Notebook file in order to run the questions in the SMART Response

system. During each plenary, a teaching assistant operated the response system on a computer and brought up the clicker questions on the screen as requested by the instructor. Meanwhile, students were invited to send their responses to clicker questions by using the hand held remote SMART XE clicker. Once all responses were submitted, students' textual responses were displayed instantly in a left-hand column on the screen, from which students could see their own and peer's responses; students' aggregate responses to multiple-choice questions were displayed in a pie chart on the screen. This display can be turned off or on depending upon the instructional need of the instructor. During each plenary, the researcher recorded field notes about instructor and student use of the clickers. After each plenary, the researcher exported student responses to clicker questions from SMART Notebook software to an Excel file, and sent the file to the instructor. Working flow of the response system in the plenary is depicted in Figure 3.1.

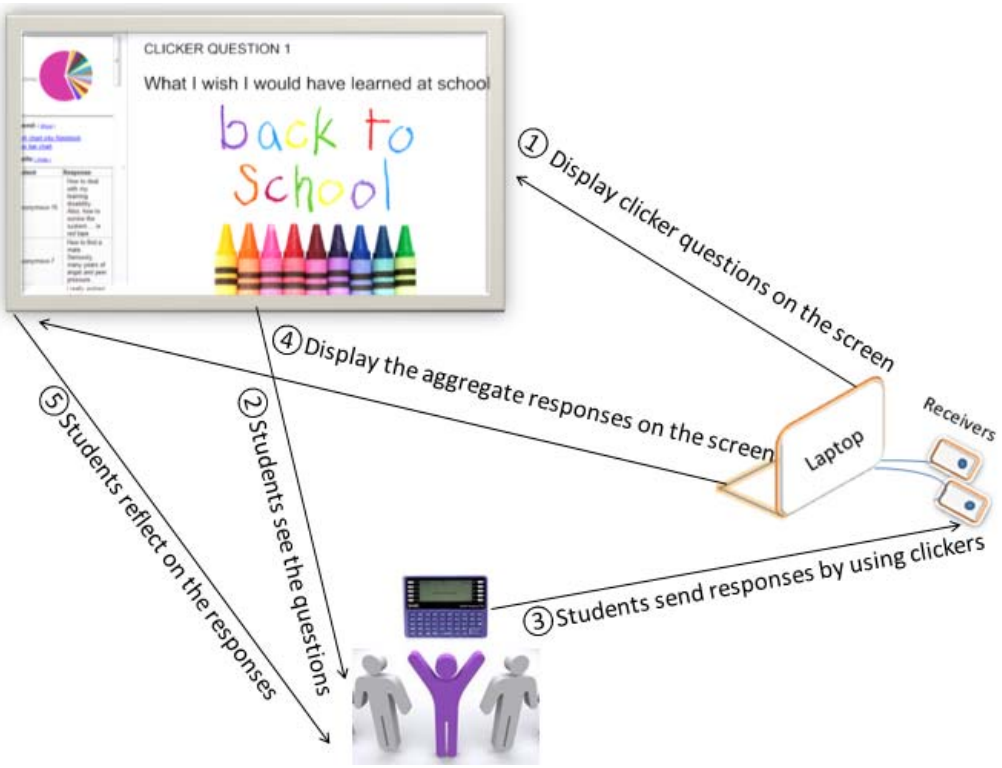

Figure 3.1 Working Flow of the Response System

Overview of the Research

This case study took place in an undergraduate teacher education plenary from January to March 2012 during the Winter semester. Major research tasks are summarized in Table 3.1:

Table 3.1 A Summary of Research Tasks

Plenary Sessions	Major Research Tasks
Plenary 1, Jan 11	Did a test run of the response system after the plenary
Plenary 2, Jan 18	Began to use the response system; Supported use of response system by instructors and students; Recorded field notes
Plenary 3, Jan 25	Recruited participants for research in the plenary
Plenary 4, Feb 1	Supported use of response system by instructors and students
Plenary 5, Feb 8	Recruited participants in another course with the same student group on Feb 7
Plenary 6, Feb 22	Supported use of response system by instructors and students
Plenary 7, Feb 29	Supported use of response system by instructors and students
Plenary 8, Mar 7	Supported use of response system by instructors and students
Plenary 9, Mar 14	Conducted student individual/focus group interviews during Mar 12-15
Plenary 10, Mar 21	Administered the student survey via the response system
After the final Plenary	Conducted a SKYPE interview with the instructor

Technology Implementation

For this study, SMART Technology's SMART Response XE system with two receivers and SMART Notebook software were installed on the existing desktop PC in the lecture hall by IT personnel. The initial trial of the SMART Response XE system went well. However, an unexpected factor in this implementation was the use of the desktop to record the lectures using ProfCast (i.e., software that is used to record live lectures including voices and visual Powerpoint slides). To reduce complexity in the technological systems, starting from the fifth plenary (Feb. 8th), the response system was installed and run on the researcher's personal laptop PC. Then, during the following plenary sessions, the desktop PC was used to run the ProfCast, the online

videos, and so on, while the response system was operated separately on a laptop PC to ensure that all the technology applications were able to work smoothly in lecture time.

For each plenary, the researcher and a teaching assistant took responsibility for transporting the five cases that contain 200 clickers from the Faculty of Education to the large lecture hall located in the Science Theatres, and for returning them to a secure storage room in the Education Tower in the evenings and returning them to the Library the next mornings. During the plenary, three cases of the clickers were distributed at three entrances to the lecture hall, and the other two cases were put in the front of the room, which facilitated students' independently picking up and dropping off of the clickers at both the beginning and conclusion of each plenary.

To make sure that the response system would work well in its first use in the second plenary, the researcher and a teaching assistant did a test run of the system with five remote clickers after the conclusion of first plenary. Since the scheduled room is a huge lecture hall containing 413 seats, the researcher sat in the far back row and tested whether the remote clickers could receive and send out information from and to the response system. The response system began to be put into use from the second plenary, during which a teaching assistant gave students a five-minute instruction regarding key steps of signing onto the response system, such as powering on the clicker, referring to the number on each clicker, selecting classes, and so on. Students were observed to learn and use the clickers quickly and effectively.

Participants Recruitment

Several undergraduate students (i.e., pre-service teachers) and a course instructor took part in this case study. The researcher employed a convenience sampling method to recruit student participants. "In convenience sampling the researcher selects participants because they are willing and available to be studied" (Creswell, 2012, p.145). The second semester lecture series

within the Bachelor of Education program, which were offered in Winter 2012 semester, provided a convenient sample of student participants and a large lecture setting within which the researcher was able to explore the use of clickers by pre-service teachers in a large lecture setting.

The target research population was all of the 375 first-year education students enrolled in the course. The accessible population was approximately fifty students, as the attendance rate of the plenary was low, usually fifty students on average. An explanation for the relatively low attendance rate might be that the plenary sessions were recorded using ProfCast and the recordings were made available to students online so that students could listen to the plenary sessions anywhere at anytime. Within the accessible population, ten students participated in focus group/individual interviews and fifteen students completed the survey. These voluntary participants who took part in interviews and the survey were from the same student group, but they were not necessarily the same students. More specifically, the ten students who volunteered to participate in the interviews might not have also contributed to the survey.

Recruitment of student participants was conducted in two different plenary series in the Bachelor of Education program. The first recruitment was conducted on Jan. 25th in the plenary within which the research data was collected, and the second one was administered on Feb. 7th in another course as the instructor of that course taught the same student group as the plenary had, and that course was expected to have a higher attendance rate than the plenary. The instructor gave the researcher the permission to recruit participants in this other plenary.

The recruitment procedures were very similar in the two different plenary series. The recruitment procedures in the clicker plenary were: 1) the researcher and a teaching assistant handed out the Student Consent Forms (see Appendix B) to students at the entrances to the

lecture hall before the beginning of plenary; 2) the researcher spent five minutes giving a brief presentation of the research to students and inviting students to participate, and a recruitment slide (see Appendix G) was brought up on screen for students' reference; 3) students read the consent form, and signed it if they decided to participate. Students were asked to write down their Email address if they indicated willingness to participate in interviews so that the researcher was able to contact them and arrange a convenient interview time; 4) the researcher and a teaching assistant collected both the signed and unsigned consent forms back. It took approximately ten minutes to complete the recruitment.

On Feb. 27th, two weeks before the conduct of student interviews (Mar. 12th – Mar. 15th), the researcher emailed an interview recruitment script (see Appendix H) to the students who had given their consent to participate in individual/focus group interviews, and invited students to pick an interview time that worked best for their schedule. For students' convenience, the researcher referred to students' course schedule in Winter 2012 semester and prepared ten interview time sessions for students to choose from that did not conflict with other scheduled class times. The researcher sent a reminder to the students who had not responded to the email recruitment one week after the initial invitation (Mar. 6th). Finally, ten students agreed to a scheduled time for an interview. The interview room was located in the Education Tower, which was convenient for students to travel to before or after their courses. During the four interview days, the researcher put a direction sign on the wall close to the interview room to guide students to the room.

The instructor also indicated a willingness to participate in this study and to contribute insights on how clicker use supported learning and teaching in the plenary during an individual interview. The Winter 2012 plenary was the instructor's first time using clickers in his/her

teaching. The researcher recruited the instructor to participate in the study by email on Mar. 1st, and set up the interview time after the end of plenary sessions.

Data Collection

To address the research questions in this case study, multiple sources of data were collected to gain a more complete view of the research context and to obtain a rich data set. The empirical evidence included observational field notes, student and instructor interview responses, student survey data, clicker question examples and student responses.

Research Instruments

Three instruments including Student Interview Protocol (see Appendix D), Instructor Interview Protocol (see Appendix E), and Student Survey Protocol (see Appendix F) were used during the data collection procedure. The protocols were initially developed by the researcher based on her interpretation of literature on active learning and knowledge building. For example, according to Michael (2006)'s interpretation of active learning as "the process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas" (p.160), the researcher created a Likert-scale survey item #11, "The clicker use provided me opportunities to have a deeper reflection on the ideas/knowledge learned in the lecture". Then, drawing upon Jacobsen & Davis (2011)'s study on student engagement with clicker use in large lectures in the same Bachelor of Education program, the researcher revised the protocols based on previous researchers' experiences, such as keeping the number of survey items less than 30 because respondents appeared to be fatigued when exceeding the limit. On Mar. 1st, two weeks before the actual implementation of interview and survey instruments, modifications were made according to the researcher's two-month first-hand observational data of students and the instructor's experiences on using clickers at the research site. For instance, due to the low

attendance rate, the researcher added an interview question, “Students have many reasons for choosing to attend or not to attend lecture. In your opinion, what are some of the factors that impact a student’s decision to attend lecture?”.

Classroom Observations

Classroom observational data were collected in this case study. Yin (2009) argued that:

> If a case study is about a new technology or a school curriculum, for instance, observations of the technology or curriculum at work are invaluable aids for understanding the actual uses of the technology or curriculum or any potential problems being encountered (p.110).

In each of the ten plenary sessions, the researcher sat in the front of the lecture hall, conducted classroom observations and took field notes on clicker activities and student group behaviors as a non-participant observer. The non-participant observer is an “outsider” who sits in an advantageous place to watch and record the phenomenon without becoming involved in the activities of the participants (Creswell, 2012). The researcher paid more attention and took field notes on the following events at the research site: 1) Clicker questions being asked and student responses; 2) Students’ learning behaviors including interactions with peers and with the instructor, students’ follow-up questions and discussions related to the clicker questions; 3) User experience of the clicker technology including students’ and the instructor’s enjoyment and difficulty with clicker use, students’ response time to clicker questions, and any technical problems or challenges that happened.

Student Individual /Focus Group Interviews

“Interviews are an essential source of case study evidence because most case studies are about human affairs or behavior events. Well-informed interviewees can provide important insights into such affairs or events” (Yin, 2009, p.108). In this case study, student interviews

were conducted to obtain rich data about students' in-depth views and opinions towards the experiences of learning with clickers.

As indicated on the consent form, student participants had the right to choose which type of interview they would like to participate in, as a result, seven individual interviews and one focus group interview with three students were conducted in the study. Different choices of interview types were offered to participants because some students may be more articulate and open in an individual interview, while other students may prefer to join an interactive focus group interview. The duration times of the seven individual interviews varied from 23:44 minutes to 57:27 minutes, and the focus group interview lasted for 45:53 minutes.

A student interview protocol using eight open-ended questions was followed during the interviews (Appendix D) and probes were used to elicit clarifying and elaborating information. The interview protocol was sent to each interviewee by E-mail one day before the interview so that participants could have an opportunity to read it and prepare for it. A hard copy of the interview protocol was also given to every participant during the interview. Efforts were made to conduct interviews of better quality: 1) At the beginning, participants were thanked for taking their time to make contributions to the study; 2) Then, participants were asked for the permission of having the interview recorded; 3) In a focus group interview with three students, it was suggested to participants that they take turns in contributing their thoughts so that each of them could have an equal voice; 4) At the end of each interview, participants were encouraged to make a concluding remark of their unique perspectives on clicker use; 5) Participants were thanked and appreciated once again. All of the eight student individual/focus group interviews were recorded by a SONY Digital Voice Recorder, and by the QuickVoice Recorder on an iPad

as a back-up, and all the recording files were transferred to the researcher's personal laptop for transcription.

Instructor Interview

After the course ended, the instructor was interviewed about his/her insights on how the clicker use assisted him/her in performing the teaching role, and on how the clicker use supported students' learning from a teacher's perspective. The researcher did a one-hour confidential SKYPE interview with the instructor. Before the starting of interview, the instructor gave his/her verbal consent for participating in the interview and for all the details included on the Instructor Consent Form (Appendix C). Later, the instructor signed a hard copy of the consent form. During the interview, an instructor interview protocol using nine open-ended questions was followed (Appendix E) and probes were generated. The protocol was sent to the instructor by E-mail on Mar. 23rd, a couple of days before the interview. The interview was recorded by the QuickTime Player on an iMac, and by the QuickVoice Recorder on an iPad as a back-up, and the recording file was transferred to the researcher's personal laptop for transcription.

Student Survey

The researcher collected quantitative data by administering a student survey (Appendix F), which aimed to gather responses from a larger population. The student survey was composed of twenty-seven five-point Likert-scale questions, to which students submitted responses ranging from strongly agree, agree, neutral, disagree, to strongly disagree. The survey was administered in the second half of the last plenary on Mar. 21st. As students' initial consent to participate in the survey was given two months previously in January, the researcher did a verbal reminder in two of the plenary sessions (Mar. 7th and Mar. 14th) and encouraged students who had given their

consent to participate. Finally, fifteen students came to the last plenary and completed the survey. During the last plenary, the anonymous survey was run by the response system as a continual assessment so that the responses to survey items would not be displayed on screen. Students used the remote clickers to send their responses to survey items, without any identifying information being obtained. Administration of the survey took approximately twenty minutes, five minutes of which were spent on introducing the survey, and on helping and making sure that all the participants logged onto the response system correctly. Later, the pie chart aggregate responses generated from each survey item were saved by the researcher to a Word document as a back-up.

Besides qualitative observational data, qualitative interview data from students and the instructor, and quantitative survey data, the clicker questions used by the instructor during lecture time and student responses to the questions were documented.

Data Analysis

Observational Data

Field notes were taken and organized under prepared categories, such as student learning behaviors, instructional strategies, question response rate and time, and technology improvement. These observational data were aggregated and analyzed using qualitative content analysis.

Interview data

The interview data served as the primary data in this study. Six analysis steps were taken in order to gain a more accurate interpretation of the interview data: 1) Transcribed the 340 minutes of interview recordings into several textual documents; 2) Initially read through the transcripts to gain a general sense of the interview content without imposing a specific analytic lens; 3) Reviewed literature on active learning theory, knowledge building theory, and the research

questions, and then identified major themes; 4) Read and coded the interview text, and identified other themes generated from the text; 5) Reviewed the literature and research questions once again, and reduced the number of themes; 6) Read the interview text once again and did a frequency analysis of the interview data.

Student Survey Data

Student responses to survey questions were used to derive frequencies and to compare with the interview data. During the analysis, the researcher found invalid data received from one survey respondent. As indicated earlier, the survey was administered by the response system. Each participant was randomly assigned a number when logging onto the response system without any identifying information associated. From the response system, the researcher could see individual participant's response time to each survey item (see Figure 3.2). The researcher noticed that starting from survey item #7 until the last item #27, one participant's response duration time was listed zero for each survey item, which means that the participant might have entered his/her response prior to the display of each survey item. In order to accurately interpret the survey data, the researcher decided to remove all of the survey responses entered by participant #15. As a result, a survey sample of fifteen students rather than sixteen was used in data analysis and reporting.

Details: (Hide)

Student	Response	Duration
Anonymous-2	B	00:00:10
Anonymous-9	B	00:00:16
Anonymous-5	B	00:00:24
Anonymous-15	C	00:00:00
Anonymous-3	C	00:00:22
Anonymous-14	C	00:00:25
Anonymous-13	C	00:00:27
Anonymous-10	C	00:00:27
Anonymous-1	C	00:00:28
Anonymous-11	D	00:00:25
Anonymous-8	D	00:00:29
Anonymous-6	D	00:00:29
Anonymous-4	D	00:00:29
Anonymous-16	D	00:00:30
Anonymous-12	E	00:00:25
Anonymous-7	E	00:00:26

Figure 3.2 Individual Response Time to Survey Questions

Triangulation

Triangulation has been employed to analyze and compare data collected in this case study to have a more valid and reliable view of pre-service teachers' experiences on learning with clickers in large lectures. Slavin (2007) defines triangulation as means that support conclusions with evidence from different sources. Triangulation brings diverse viewpoints that can cast light upon a topic or issue and give a more detailed and balanced picture of the research context (Altrichter, Posch, & Somekh, 1996; Olsen, 2004).

The most desired triangulation occurs when three (or more) independent sources all point to the same outcomes, which makes research findings as robust as possible (Yin, 2012). Under each of the themes that was used to frame the data analysis in this case study, student interview feedback served as the major source, and at least one of the other four sources, including instructor interview feedback, student survey responses, classroom observational field notes, clicker question examples and student responses, was used and analyzed to confirm or compare with student interview findings, or to identify events or behaviors that were unable to be covered

by student interviews. Yin (2009) also argues that using multiple sources of evidence to support the research findings can increase the validity and reliability of a case study research design.

Ethical Considerations

Ethics approval (see Appendix A) has been granted by the Conjoint Faculties Research Ethics Board, University of Calgary, before conducting the research. Participation in this research study was completely voluntary. Students had the right to choose to participate either in a confidential interview or an anonymous survey, or in both, or in none of them. Student participant's course grade was not be affected by participation, non-participation or withdrawal. All the activities student undertook with the response system were anonymous, including logging onto the response system, responding to clicker questions, and participating in the survey. In this research, no individual identifying information was obtained, and participants were only identified as the student group and the course instructor. The researcher and the interviewees all made efforts to protect the confidentiality and anonymity of interviews, for instance, it was advised to the participants that they should not use each other's name in a focus group interview, and not discuss any of the interview content after the completion of interviews. Research data is stored in a secure environment and will be permanently destroyed according to the ethics guidelines.

Conclusion

This chapter describes details on how this case study research was designed and carried out, and how the data was collected and analyzed in order to gain a more valid and reliable understanding of how the use of clickers in a large, undergraduate lecture learning experience may engage pre-service teachers in active learning and knowledge building. Chapter Four presents an analysis and interpretation of the collected data.

CHAPTER 4 ANALYSIS OF DATA

This chapter presents an analysis of data collected in this case study. The chapter is divided into four sections: 1) active learning, 2) knowledge building, 3) user experience and 4) future use. The first section analyzes students' and the instructor's perspectives on how the clicker technology supported students to actively learn in large lectures. The second section interprets students' and the instructor's perceptions on how the clicker technology supported students to collaboratively build knowledge in a large lecture setting. Section three reflects on students' and the instructor's use of the technology, ease of learning and overall satisfaction with the clicker technology. The fourth and final section summarizes students' and the instructor's suggestions on the improvement of instructional and technological use of clickers. Figure 4.1 provides an outline for this chapter:

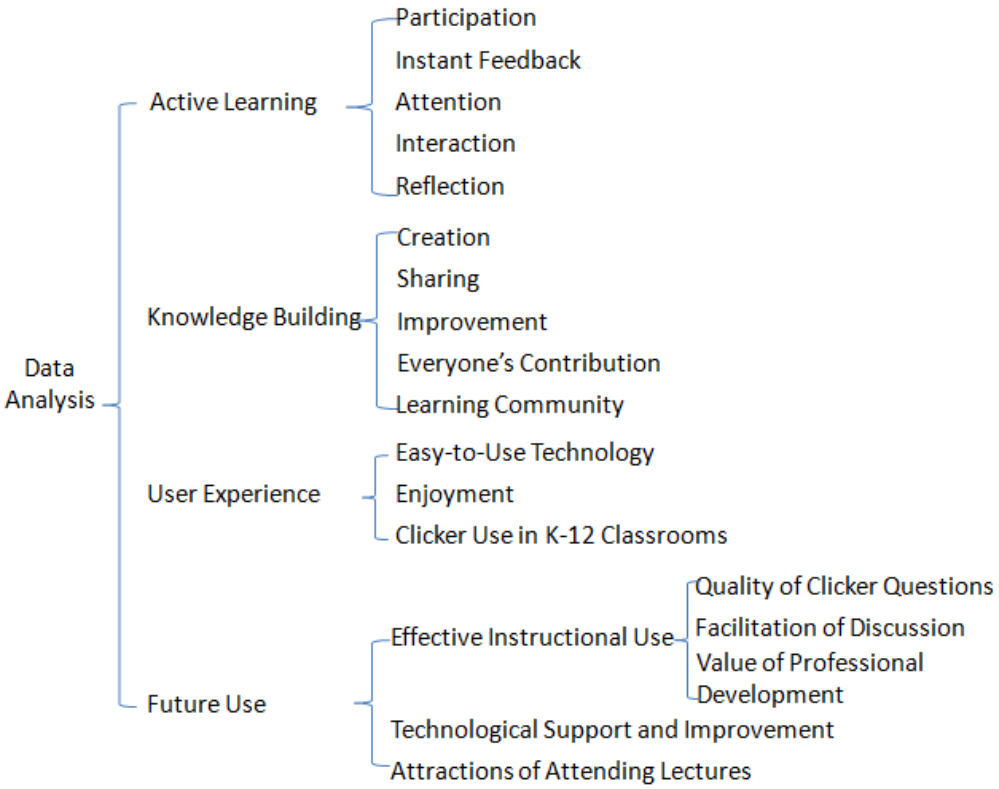

Figure 4.1 Outline of Chapter Four

Active Learning

Opening Remarks on Active Learning

Generally, with regards to active learning, seven of the ten student interviewees (70%) enthusiastically agreed that the use of clickers in the plenary provided them the opportunities to be engaged in active learning. Three of them (30%) agreed that while some active learning was promoted with clicker use, the active learning could have been even more effective if, for example, the clicker technology was integrated with the course materials at a deeper level.

The majority of student interviewees (70%) compared their experiences in this plenary to previous learning experiences and summarized that, in traditional lectures without the use of clickers, there tends to just be a one-way instructional style where the professor is talking during the whole lecture time and the students are just passively sitting there, listening and taking notes. However, with the use of clickers in this plenary, students reported feeling more actively engaged in their learning by answering the clicker questions. Direct quotes from interviews with students illustrate their views on active learning with clickers:

> *"Typically a lecture has no active learning going on, just absorb knowledge. It goes in one ear and comes out the other."*

> *"It (the clicker use) is just a simple way of switching it (lecture) from passive to active."*

The instructor reported that she believed that the use of clickers provided students with opportunities to engage in active learning, and that clicker use made the lecture hall a more active learning environment. During the interview, the instructor commented on active learning in this way:

> "*We know, in adult education, that the attention span of students, is really time limited, so using the clickers…I think a different part of the brain then started to kick in, they (students) become more involved in the actual learning environment, they had an*

> *opportunity to speak through the clickers…I think that the clicker technology turned the lecture theatre from a passive learning environment to an active learning environment.*"

Interview feedback from both the students and the course instructor indicates that a more active learning environment can be supported with use of clickers and response questions in the large lecture.

According to the definitions of active learning (Michael, 2006; Waitz, 2002) and the characteristics of active learning environments (Bonwell & Eison, 1991; Chickering & Ehrmann, 1996) used in the Literature Review for this study, the researcher has organized the following sections to elaborate on how clicker use seems to have supported students in becoming more active at their learning in large lectures by: 1) increasing participation, 2) gauging instant feedback, 3) being more focused, 4) promoting interaction with the instructor and with peer students, and 5) facilitating a deeper reflection of the learning content.

Participation

The majority of student interviewees (70%) reported that the clicker use tended to increase their participation in lectures. For example, during the interviews, students discussed participation in these ways:

> *The overall benefits of using clickers in the lecture, "I guess, for me, active participation and being engaged."*

> *"Just being more involved in the lecture than just sitting and taking it, the more participatory aspect was good."*

> *"So you're not just sitting there, you're actually part of the lecture."*

The feedback gathered from students using the in-class survey (n=15) presented a diverse set of opinions regarding participation. In response to survey item #4, "My participation/contribution in lectures was increased because of clicker use", 40% indicated agree

or strongly agree, and 13% indicated disagree or strongly disagree. What is challenging to interpret is the large percentage (47%) that indicated they were neutral about any increase in participation. It may be the case that respondents participated more in some of the lectures because of clicker use, but not in all of the lectures, and therefore they chose to indicate a neutral level of agreement.

Instant Feedback

The majority of student interviewees (60%) noted that one of the biggest benefits of clicker use in large lecture was that both the students and the instructor can get instant access to the group responses to clicker questions, either in pie chart or text formats, to guide their learning and teaching. Students detailed the benefits of instant feedback to both the instructor and themselves in these ways:

> *"I think the best benefit is really for the instructor to gauge where the students are as a class, cause often that's missing when you have such huge (student) numbers.*"

> *"So it's interesting to see, like pretty quick, like the deviation across the groups, differences across people in the class."*

In response to survey item #10, "The clicker use provided me opportunities to immediately apply the knowledge learned in the lecture", the majority of students (60%) indicated agree or strongly agree, and 13% indicated disagree or strongly disagree. Both the interview and survey responses from students indicate that the immediate feedback provided by the audience response systems is believed to be valuable for learning and teaching.

Attention

Cognitive load theory (Pass & Sweller, 2012) suggests that learners tend to have a limited or finite attention span in whatever format of classroom. Two student interviewees and the instructor reported that the clicker use helped students pay more attention in the plenary,

especially when they were involved in answering clicker questions about the lecture content. One student elaborated the point:

> "*I think it kind of helps you engage in active learning because of it breaks up the monotonous nature of a lecture…Even if the speaker is really engaging and you are really interested in what they are talking about, if it is an hour and a half lecture, or even a fifteen minute lecture, you can't focus throughout the whole time…even if you are focused for the majority of the time, it's nice to have something to kind of break up the talking a little bit and get you to engage and reflect on what you are doing and then it kind of helps you to refocus.*"

Interview feedback from both the students and the instructor indicated that responding to clicker questions functioned as a break-up in the plenary, provided time for discussion and reflection, and helped students to refocus on key course topics.

Interaction

The survey responses from almost half of the students (47%) indicated that they agreed or strongly agreed with item #5, "My interaction with peer students was enhanced because of clicker use". This finding from the survey is supported by feedback from student interviews:

> "*There's a chance to get interaction with other students even if I am not talking to them…The clicker technology is a dedicated technology to this classroom's interaction.*"

> "*We'll be interacting with each other in the only way you can get 400+ students to interact together.*"

The survey responses also showed that a little over half of the students (53%) agreed or strongly agreed with item #6, "My interaction with the instructor was enhanced because of clicker use". This survey finding is complemented by the feedback from the instructor on increased interaction between learners and the instructor.

The instructor further indicated that the clicker use enhanced his/her interaction with students, as well as promoting the interaction amongst student themselves in a large lecture. To quote the instructor:

> "*The Science Theatre was very large, physically it makes it difficult to form a connection with the individual students…But as an instructor, as a lecturer, it left me feeling so much more connected to the students, because I was able to, particularly in the clicker questions that asked for a narrative response, it gave me an opportunity to hear from individual students that I wouldn't necessarily have heard if I hadn't had the clicker technology. I thought it was excellent.*"

> "*But I also think it helps students to feel more connected with other people in the Science Theatre. Because in the open text, they were, they became part of a larger conversation by seeing the responses of others.*"

However, in response to survey item #5, almost half of the participants (47%) indicated that they disagreed or strongly disagreed that their interaction with peer students was increased because of clicker use. Also, regarding the responses to item #6, 27% of the participants disagreed or strongly disagreed that their interaction with the instructor was enhanced because of clicker use. One possible explanation for why a relatively large portion of participants did not feel increased interaction with each other in the plenary might be that they did not have enough opportunity to talk to peers and to the instructor even though they were using clickers. Elaborative feedback from classroom observations indicated that when there were more students present in the lecture hall, they had relatively more interaction with peers sitting around at the time of answering clicker questions, whereas when there were fewer students, they just silently sit there and entered their responses individually, having less or even no interaction with peers, perhaps because they were so spread out in such a large lecture hall. So, one can observe that the simple matter of how many students are present, and how closely they choose to sit together, can influence the level and quality of interaction among participants even when using clickers.

Reflection

The majority of student interviewees (70%) indicated that writing or choosing an answer to the clicker questions really helped students reflect on their learning. Two students further

reported that the finding of more reflection on their learning was based on the fact that the plenary is a very reflective course where there was space to explore personal opinions and beliefs, and intentional inquiry into where the students stand as learners on certain issues.

Half of the student interviewees addressed the opportunity for increased reflection, especially when answering the open-response questions. Students indicated that they really had a chance to spend some time organizing thoughts and selecting vocabulary to portray their thoughts when asked to respond to an open-ended question. Here are two direct quotes from two students:

> "*It did give a chance for reflection at the moment because you have to write something down, you have to think about it. And if you have to write something down in 20 words or less…you have to think about what's really important, what's the few words I wanna use to get it across…that would not have happened in a traditional lecture.*"

> "*It is an opportunity to just, you know, take a minute or two in the lecture time and actually reflect, you know, get your ideas together and put them in the writing…articulate your own thoughts.*"

Two student interviewees commented that the short, 140-character open-ended textual response generated using the clicker is like a Tweet (i.e., Using Twitter, an online social networking application, contributors create individual Tweets which are 140 characters or less), which required students to contribute a concise, subtle, and thoughtful reflection in class.

There was some discussion amongst interviewees on the length of the open response. Some student interviewees wanted the opportunity to contribute a longer response, while the majority of them indicated preference for a short one. Advocates of a short, open-ended response reflected that the majority of students believed that the purpose of asking a clicker question was "*to get that quick, instant feedback to read on the spot*" instead of "*writing an essay on the clicker*". One student further claimed that as a future educator, s/he has to think very carefully of the means

used to communicate, so writing the Tweet length response made him/her focus on how to effectively express oneself and how to be a better communicator.

Besides the open-response clicker questions, one student claimed that the multiple-choice question was also able to help students reflect on their learning. The student said,

> *"…especially if it's just an ABC or D multiple-choice, it can be easy to just pick one. But if it's a multiple-choice question and they are asking 'what position you've seen something or how do you see it?', you kind of have to think about where you put yourself and why you would answer that ABC or D."*

The survey response also showed that the majority of students (67%) agreed or strongly agreed with item #11, "The clicker use provided me opportunities to have a deeper reflection on the knowledge learned in the lecture".

Responses from student interviews and student survey suggests that both the process of writing a Tweet length, concise response to an open-ended question, and the process of choosing a stance towards a multiple-choice opinion question helped students to reflect upon their learning at a deeper level.

Concluding Remarks on Active Learning

Based on the analysis of responses gathered from student interviews, instructor interview, student survey, and classroom observations, this research has found that the clicker technology appears to support students in shifting their role from a passive learner to a more active learner in a large lecture setting, and that clickers can be used to support a transformation from a passive lecture environment to a more active and engaging learning environment. The following "*Knowledge building*" section illustrates to what extent the clicker use supported students in promoting their active learning to a higher level of knowledge building.

Knowledge Building

Opening Remarks on Knowledge Building

Eight of the student interviewees (80%) enthusiastically agreed that the use of clickers provided them with opportunities to engage in knowledge building (i.e., collaborative creation and improvement of knowledge that has value to the community) in large lectures. Two of the participants agreed that while some knowledge building was promoted with clicker use, it could have been promoted even more. One suggestion for promoting more knowledge building was to allow for more discussion amongst student themselves after seeing the group responses to clicker questions.

Three student interviewees realized that knowledge building usually takes place in small classes where students have more opportunities to collaboratively create, share, and improve knowledge, for example, in small group discussions. However, all of the ten interview participants (100%) did believe that the use of clickers added possibilities of knowledge building in large lectures. One student provided this insight:

> *"I think with the clicker questions and the clickers, it kind of adds new dimension to knowledge building in a large lecture environment. It really allows you to share, inquire, and to build that knowledge, whereas maybe without them, you won't be able to do that because you won't have so much time, if you have 400 people in the class, to ask what their opinion is, right? I know a lot of time people won't share.*"

The instructor also believed that the use of clickers provided students with opportunities to engage in knowledge building by expressing their unique ideas, learning from peer students' ideas, and building a connection with each other.

> *"I think that by seeing their narrative response on the screen, it then gives them an opportunity to reflect on what it is they just said, so it's no longer a thought that is in their head, they have expressed it, they have taken something implicit and made it explicit. And then they can look at that, and they can also then look at how their response connects, or aligns, or informs or not other people's responses. So I think it helps the students to feel a*

connection with others, and it also helps students to become aware of the knowledge that other students have, so we then can kind of co-create knowledge together."

Three of the ten student interviewees stated that they associated knowledge building more with the open-response questions than with the multiple-choice questions. The instructor also expressed a strong preference for the open-response questions, which he/she thought could help students locate themselves in a bigger discourse and could support more critical reflection. The instructor thought the multiple-choice questions,

"…tend to focus more on informational items, you know, you get a surface view of a student's response. But the narrative is almost more qualitative, it gives a lot more substance, a lot more depth, and it provides a lot more meaning".

The survey responses, summarized in Table 4.1, confirmed high levels of student agreement that the use of clickers could engage learners in knowledge building in large lectures, especially with the opportunity to answer open-response questions.

Table 4.1 Survey Responses Regarding Knowledge Building

Survey Items	Agree or Strongly Agree	Neutral	Disagree or strongly disagree
#12 The clicker questions and associated discussion supported a **creation** of ideas/knowledge.	73%	13%	13%
#13 The clicker questions and associated discussion supported a **sharing** of created ideas/knowledge.	73%	20%	7%
#14 The clicker questions and associated discussion supported an **improvement** of ideas/knowledge.	60%	27%	13%
#15 I felt that the open-ended (text-entry) clicker questions provided more opportunities to create, share and improve idea/knowledge than close-ended (multiple-choice) ones.	73%	7%	20%

Seventy-three percent of respondents expressed a high level of agreement that clicker questions and associated discussion supported both a creation and sharing of ideas and knowledge (see Table 4.1). Additionally, survey respondents indicated a high level of agreement (73%) that the open-ended clicker questions provided more opportunities for knowledge building activities that close-ended clicker questions.

In general, the feedback from student interviews, the instructor interview and student survey responses indicates that the clicker use, especially when integrated with open-response questions, can provide students with opportunities to create, share, and improve their ideas or knowledge in the large lecture.

Creation

Four of ten student interviewees articulated that when answering the open-response clicker questions, students had the opportunity to gauge where their knowledge is, think about their perspectives, actively form their ideas, and to express their thoughts and understanding, which is what knowledge building means for them.

For example, the instructor used this question with the clickers, which asked, “What does lifelong learning mean to you?”, and in responses, students expressed diverse meanings of lifelong learning using the open-response format (see table 4.2).

Table 4.2 Student Responses to a Clicker Question (A)

Student 1	Brings passion, inquisitive, seek questions, build ambiguities, seek balance and harmony, challenge ourselves
Student 2	Always seeking out new information in areas that you are passionate about so that you can be well informed and make a contribution to others
Student 3	A continual daily process of coming to realize oneself through deliberate and effortful practice...making new mistakes as often as possible!

After displaying student responses, the instructor introduced several authoritative definitions of lifelong learning, and then one student was observed to question and doubt one of the authoritative definitions based on his/her own interpretation. This type of instructor-student interaction and debate over rich content and ideas implies that the clicker technology can provide an avenue of constructive use of authoritative information.

Another open-ended question used by the instructor was, "Do all students in our education system have access to full citizenship through education?", in response to which students offered creative interpretations of student's full citizenship (see Table 4.3):

Table 4.3 Student Responses to a Clicker Question (B)

Student 1	All students have access to citizenship through education, but it depends on the extent to which teachers successfully push for it...
Student 2	No, because each student has different learning needs which are not always addressed
Student 3	No, because education system reflects and perpetuates same inequalities present in society at large

One student gave further elaboration on the knowledge creation supported by clicker use in the plenary:

> *"So I think there are two different things going into the process of writing an answer on the clicker, one is knowledge creation, and I think that was valuable; and the other is having small group discussions about the topics, in that case, you have to verbalize your answer, which is a different process. I like a different thinking process, a different creation process. So I think that they are both important.*"

Feedback from classroom observations, examples of clicker questions and student responses, and information from student interviews suggests that the process of thinking, writing and verbalizing thoughts by responding to clicker questions supported students in creating and building knowledge.

Sharing

The majority of student interviewees (90%) stated that showing the responses to clicker questions on the screen enabled students to see, share and learn from the group's diverse opinions and positions on issues. The instructor also agreed that having immediate access to the diverse responses gave students the opportunity to have a deep and rich sharing of individual voices, perspectives and opinions, especially with the open-ended textual responses.

Three of ten student interviewees believed that the diverse ideas of the group would otherwise be hidden in a large lecture without the use of clickers, and the clicker questions and student responses just "*acted as a means or a venue for that sharing to happen*" in a large lecture. Another three student interviewees stated that they enjoyed seeing and learning beyond the professor's or the textbook's perspective in these ways:

> "*When you can hear your colleague's opinions about things or views about things, than not just listening to the professor's the whole time, you know, everyone's contribution is important for me in my learning.*"

> "*I find a lot of that course celebrates about broader ideas, and so it's more open…It's more sort of discussion of ideas and approaches and theories.*"

The survey response to item #16, "I appreciated and valued the diverse ideas raised by peers in response to clicker questions and the associated discussion", included 93% of respondents who agreed or strongly agreed and 7% who chose a neutral response. Feedback from interviews confirmed the finding, and student interviewees used different terms to describe their responses after seeing the diversity of views expressed using clickers (see Figure 4.2).

Figure 4.2 Students' Impressions of the Diverse Responses

One student articulated that:

> *"I found that I was generally surprised and intrigued by other students' responses on the clickers, because they are so varied…almost everybody interpreted differently from me and differently from each other, and that's fascinating to me and just makes it more interesting, so my horizons where I take on the question is broadened."*

The majority of student interviewees (60%) said that some of the opinions were those that they had not even considered before. One student further commented that student responses may be close to the same ideas, but everyone uses different vocabularies, so the responses are not quite worded in the same way because students used different means of expression and put different emphases in their responses.

For example, there was an open-ended clicker question that asked students, "what I wish I would have learned at school?". In response, students shared diverse opinions about what they wished they had learned at school, like "*how to enjoy life*", "*citizen rights*", "*financial management*", "*how to take care of myself*", and so on.

In addition, the majority of interviewees (70%) reported that the anonymous nature of clickers provided a safe platform for students to be open and to share their true opinions. Two students said:

> *"I was surprised how open people were, like the answers people were giving were very personal, like things you probably won't share, maybe even one-on-one or something with someone, but they were okay to share with clicker, cause no one knows who's who, right?"*

> *"I love the open-response. I was surprised that you had actually written things out. I thought, 'oh, this could get dangerous'. No, it actually, and then the more we used it, the more comfortable with us feeling with it…because this person actually wrote something that was fairly personally or wrote something that was fairly lengthy, so then you can start breaking away from what's safe and start responding with what's more truth."*

One student threw out an interesting point that s/he was more willing to accept diversity in text than in verbal, partly because s/he thought it quicker to get to the main idea in text, and partly because s/he would not have any pre-conceived notion or prejudice towards certain opinion if it was expressed in an anonymous textual response.

Besides the sharing of open-ended textual responses, two student interviewees said that they enjoyed seeing and learning from the pie chart aggregate results of multiple-choice questions.

> *"It was interesting to see that, like so many of the class have that opinion, and so many of the class have that opinion, and I have this opinion which is different, so that's what was really impactful for me."*

Feedback from the multiple sources of data indicated that the immediate access to student responses to clicker questions, whether in textual format or in pie chart, offered a valuable learning opportunity for students to share individual ideas in a larger group and to learn from the diverse ideas of other students. The anonymous attribute of the clickers facilitated and enhanced a more open and public sharing of authentic perspectives by students.

Improvement

The majority of interviewees (90%) believed that the sharing and reflection on the diverse responses helped to improve their learning in a number of ways.

Four of the student interviewees said that the diverse responses stimulated them to critically **reflect** on other students' perspectives. Direct quote from one student is presented:

> *"If you answered one way, but everybody else answered completely different from you, it kind of makes you think of, like why did they answer different from me, right?... So it kind of helps you to critically reflect on what other people are saying.*"

Two of the student interviewees said that the diverse responses motivated them to **compare, combine or align** their own perspectives with other students' perspectives.

> *"That person's opinion does fit here, and that person's opinion fits here. That person's opinion doesn't fit with my view, and what does that mean? Does that mean they are coming from a different place? Does that mean something is wrong with my view? Does that mean something is wrong with their view? Does that mean that maybe we should put the two together and there'll be something completely different?"*

Six of the student interviewees said that the diverse responses provoked them to **think differently**. For example:

> *"It opens up to a brand new dimension, a brand new point of view that, you know, allows whatever topic we are looking at to be viewed in a different angle."*

Three of the student interviewees said that their perspectives might be **changed** after reflecting on the diverse responses.

> *"The students might interpret something differently, and so after seeing the results, may be a different perspective, your perspective might change."*

Four of the student interviewees said that their perspectives might be **expanded** after reflecting on the diverse responses.

> *"Cause a lot of time you think very narrow-mindedly, you have your perspective based on your ideas, the way you look at your life. And seeing how other people answer questions,*

> *whether it was similar or different from yourself, I think kind of gets you to broaden your perspective a little bit."*

One of the student interviewees said that the reflecting on the diverse responses might **spark new ideas**.

> *"I think sometimes, it can spark new ideas and become like 'oh, I never thought of in that way, but that makes sense', and you can come up with similar things to other people that are saying that makes sense to you, but you just needed someone else to kind of spark that idea."*

One student interviewee summarized that the open-ended textual responses to clicker questions "*actually open up an interesting new avenue/discussion wouldn't come up otherwise*". In addition, three students figured out that seeing the pie chart results of multiple-choice questions also was also an opportunity to improve their learning.

> *"There's a sense of wonderment, like, 'how was it that they have that opinion?' They have different opinion from me, that's great, and how do they get theirs?"*

One student offered an important point of the premise of knowledge improvement:

> *"So trying to build on, trying to taking in a bunch of other opinions/ideas if I don't have my own, I think is counter-productive to learning, and it's only when I have a starting point, then I can build on."*

In general, one student said that "*I do think that one's self-improvement comes out of it…well then obviously it's making you aware of what your assumptions were, and then see how you have to adjust that*". However, another student contributed a point that the extent to which the clicker questions and its responses could engage students in knowledge building depends on an individual's choice. S/he interpreted that although internalizing or building on other's knowledge is a student's responsibility, some students may use it as an opportunity to collect their thoughts while some students may not.

Feedback from student interviews and student survey responses indicated that students could learn from the diverse responses by critically reflecting on peer's responses, and comparing, combing or aligning peer's responses with themselves. As a result, 1) students could be engaged in thinking about their own responses from a different perspective, 2) students' initial responses might be enhanced, expanded, or changed, because of their access to group responses, and 3) brand new ideas could be sparked during the reflection process that is sponsored by clicker questions.

Everyone's Contribution

In order to build a community (McMillan & Chavis, 1986) where students collaboratively pursue their learning goals, every student is expected to make contributions to their learning in lecture time. Given the design of conventional instructor lead, large lecture learning environments, it is not always possible for everyone to make contributions or to express an opinion. During interviews, student respondents listed several factors that they argued would affect a student's decision to contribute or not in a large lecture setting:

- A large number of students: if all of the 375 students had actually come to the lecture, it would be difficult to give each person an opportunity to speak in such a big class, and as a result, a lot of voices would get lost (one student indicated).
- A few aggressive students always put up their hands and dominate the discussion time (four students indicated). *"I didn't get my hand up fast enough or the professor is now just used to looking at that corner of the room because that's where the answer comes from."*
- Some students are less inclined to speak up in large group compared to a smaller group (three students indicated).

- Some students are quiet/shy/introverted and seldom speak up or raise their hand (three students indicated).
- Some students (ESL learners) are not comfortable with English (one student indicated).

When asked to explain why students may not contribute during a large lecture, the instructor suggested that gender may be a factor, or individuals from various cultures may not speak up in group situations, and there are also students who are more comfortable texting their thoughts than talking.

The majority of student interviewees (70%) and the instructor all agreed that the anonymity that clickers provide does encourage students who may be uncomfortable speaking up in large lectures to frankly express their thoughts, and as a result, more opinions can be heard and more people can be directly engaged in providing their perspectives. Two students discussed in these ways:

> "*It allows you to kind of drop your guard a little bit and contribute anonymously.*"

> "*People who are introverted, so who don't like to speak out in a big group can also have their say without feeling like the spotlight is on them, so that does mean there's more overall engagement in the class…increases the overall richness of the dialogue…It's a much broader discussion.*"

In response to survey item #21, "The clicker use encouraged me to share individual beliefs publicly because of the anonymity that the clicker provided", 60% strongly agreed, 7% agreed, 27% stood neutrally, and 7% disagreed. During an interview, one student reported that when responding to clicker questions, each of the students could get a chance to contribute where

> *"…everyone is building on each other's knowledge that way, and you can create knowledge that way too, because everyone's taking part and everyone's putting forth an answer. With the clicker questions, it allows everyone a chance to take part and share in the knowledge building."*

In addition, the instructor suggested that the anonymous clicker technology could be made full use of in order to encourage students to discuss sensitive topics in class.

One student teacher further commented that the hand-held clicker remote is more anonymous and more efficient than low-tech clickers, such as response cards (i.e., different colored cards that students would physically display during lecture). During his/her teaching practicum, the student teacher once saw children in a classroom write their answers on a small whiteboard and hold it up, but questioned the effectiveness of having 400 students hold up the whiteboards simultaneously. Obviously, the whiteboard, one kind of low-tech clicker, is not anonymous and efficient enough to get quick feedback from students, nor does it allow for storage and display of the responses in textual or pie chart format.

Feedback from student interviews, instructor interview and student survey indicated that the anonymous clicker use can increase the possibility of engaging every student in expressing their unique thoughts and in making contributions to their own and to others' learning during a large lecture.

Learning Community

Four student interviewees and the instructor all believed that the clicker technology did contribute to building a learning community in the plenary, as everyone was taking part and the whole class was brought together. Students and the instructor's perceptions of how the clicker use helped foster a learning community are summarized and illustrated in Figure 4.3.

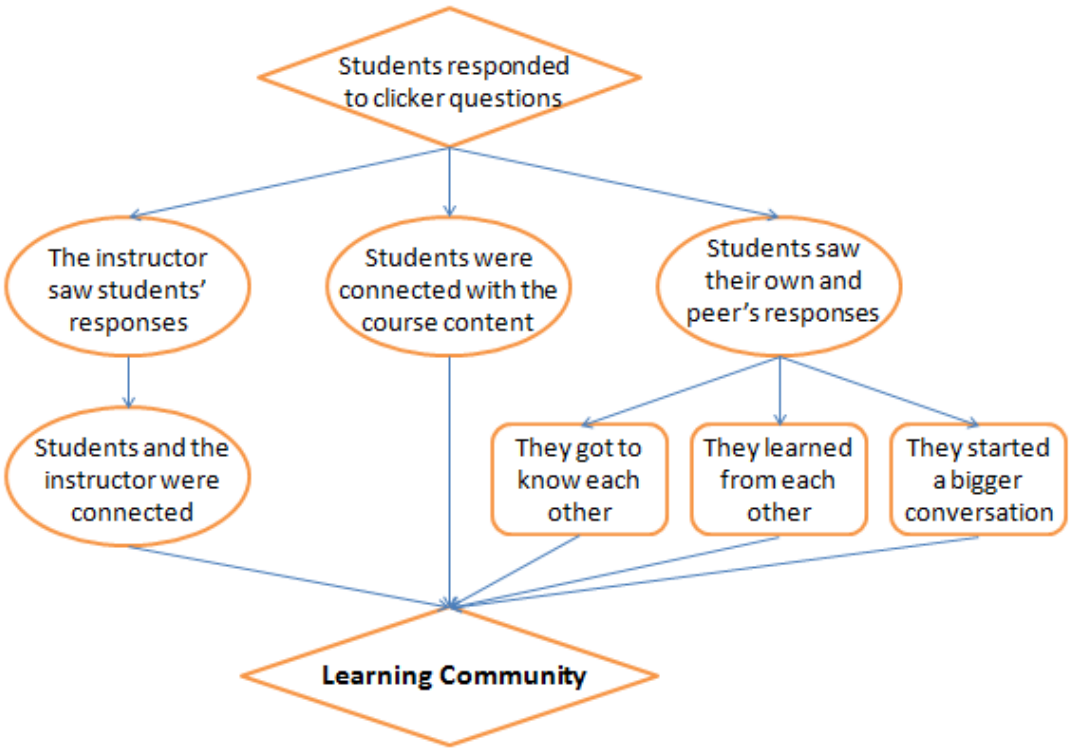

Figure 4.3 A Learning Community Fostered by the Use of Clickers

By responding to the clicker questions and reflecting on the group responses, a learning community could be established in the large lecture within which, 1) students could know and learn from each other, and could initiate a richer dialogue among themselves; 2) students could interact with the learning concepts; 3) the instructor could gauge an understanding of where the students' learning is at.

The survey responses suggested that the majority of students agreed the clicker technology could help form a learning community in large lectures (Table 4.4).

Table 4.4 Survey Responses Regarding the Learning Community

Survey Items	Agree or Strongly Agree	Neutral	Disagree or strongly disagree
#19 The clicker use helped to establish and to develop a community where we learned in a collaborative way.	60%	7%	33%
#18 I felt that my contribution in the lecture added value to the whole class's learning.	73%	13%	14%

However, four student interviewees (40%) argued that the large lecture hall made it a little bit difficult to form a learning community. The four participants said that if there were not as many people as anticipated (375 students) attending the lecture, it would be better to have a smaller classroom instead of a large lecture hall so that students would not feel so spread out, so far apart, and would feel more trusting, and more a part of a learning community where the level of participation, interaction and discussion could be increased.

Feedback from student interviews, instructor interview and student survey indicated that the clicker technology may have contributed to the forming of a collaborative learning community where students were more closely connected to peers, the instructor and the learning content. In addition, good feedback on how to better form a learning community was shared that provides insights for future instructional designs and effective clicker use.

Concluding Remarks on Knowledge Building

Based on the analysis of multiple sources of feedback, it can be argued that the anonymous clicker technology can offer every student an equal chance to take part and to be engaged in their learning in large lectures where students can collaboratively create, share, and improve their own and the whole class's understanding of key course ideas and issues, as a result, a collaborative learning community could be established.

User Experience

Overall, the majority of student participants and the instructor enjoyed the fun and unique experiences of using easy-to-use clickers to support learning and teaching, and indicated a desire to use clickers in their future learning and teaching journey.

Easy-to-Use Technology

The majority of students (87%, n=15) agreed or strongly agreed with survey item #1 "I felt comfortable using clickers in large lecture", 7% stood neutrally, and 7% disagreed.

Four student interviewees commented that the clicker technology is an easy-to-use technology, as the majority of students are familiar with texting in their daily life. One student said that:

> "*I mean likely we were in this kind of generation where it's becoming a little more second nature to be thinking about status in tweeting and things like that.*"

The instructor also agreed that the students were easily accustomed to the clicker technology.

> "*Its physical nature of a hand-held device that can be used for texting really was very comfortable for the majority of students because they are so used to texting on their iPhones, on their hand-held devices, working with Facebook. They are really comfortable generally with technology…The type of technology was something that was really intuitively aligned to the demographic of the student.*"

Although the clicker technology is an easy-to-use technology, three student interviewees noticed that students occasional forget how to sign onto clickers, partly because of the fact that clickers were not used frequently in the plenary (i.e., once in each plenary and seven times throughout the semester), and partly because there were four different class options to choose from when signing onto clickers, and some of the options were invalid. And one student commented that "*If you are using the clickers a little bit more frequently, then people will remember how to use it.*"

In order to help students who forgot the steps of signing onto clickers, two students advocated preparing a slide indicating "*step 1: power on, step 2: education 408, option 1*", and so on. One student advised on how to give instructions of clicker use to students in this way:

> *"I think those good how you introduce it at the very first lecture, as how to turn it on and everyone did it together. I think for future, maybe the second time, very briefly going over it. But for the future, I think, just having the slide up there, and not even, you might not have to talk about it, but just having the slide, or maybe on the chalkboard."*

The strategy of preparing a slide is also aligned to the characteristics of adult learners. One student elaborated that:

> *"If someone's not sure how to do it and they have no one to ask around them, too, they may feel embarrassed to ask, 'oh, I should know how to do this now, but I don't, I'm just not going to respond'…And I think that's with working with adults…So if you are providing a slide or whatever, so they don't actually have to ask someone, they can figure out that way."*

The student's argument is confirmed by the observational feedback. Throughout the semester, only three students were observed to put their hand up and to ask questions about how to sign onto the response system. However, in one plenary (March, 7), the researcher chose to sit with the student group and found out that some students did forget how to sign onto clickers and asked peer students for help, so having a slide showing the steps can be helpful.

Feedback from students and the instructor indicated that the majority of students regarded the clickers as easy to use for sending their responses, as they were familiar with texting technology. However, regularly showing a slide of procedures on how to sign onto clickers may be helpful for students, especially for adult learners who might not ask for help if they forgot the steps.

Enjoyment

In response to survey item #26, "I would like to enroll in another education course that uses clickers as part of the learning activities", 47% strongly agree, 13% agree, 27% stood neutrally, 13% disagree or strongly disagree.

Three student interviewees said that they really enjoyed the use of clickers, especially with the opportunity to move away from just multiple-choice clicker questions to open response ones. Direct quotes from students were:

> *"I think it's really fun, like I really enjoy using the clickers, it's pretty excited to use it. It's like taking a little quiz or kind of like in a fun way, cause there's no pressure and you are not being tested or anything like that."*

> *"It's a unique experience compared to, I guess, any other class I had so far, just that really due to write down the responses instead, rarely clickers can do that, those just like ABCD, multiple-choice."*

The instructor also expressed his/her enjoyment of using clickers in the plenary and indicated that in the future, s/he would like to use clickers in a plenary and even in a small class. The instructor said that:

> *"I just love the technology so much…I just want to express my appreciation to having this opportunity to work with clickers. It adds a whole other area of potentiality to my teaching, and I definitely want to incorporate clicker technology. I feel that it can really add to the pedagogy of a learning environment in that it provides another avenue for adult learners to be engaged to express their voice, and I wouldn't have known that without (clickers), so I really appreciate it.*"

Observational feedback confirmed that students appeared to experience a high level of enjoyment with clicker use. The researcher observed that at the time when the first clicker question was asked, students gave applause to encourage the last student who had not sent his/her answer to respond. The researcher also observed that when the first open-response clicker question was asked, one student capitalized all the characters in his/her response.

Feedback from various types of responses reported that both students and the instructor were excited about the new experience of using clickers in learning and teaching. While 60% of survey respondents indicated a desire to use clickers in a future learning experience, it would be interesting to investigate further with those who indicated they were neutral or disagreed that further clicker use would be welcomed.

Clicker Use in K-12 Classrooms

Based on the good experience of using clickers in the plenary, all of the ten interviewees (100%) said that they would like to use clickers in their future teaching. Two respondents indicated that they had observed kids' enjoyment and capabilities with using clickers in these ways:

> "*I know in my field experience last term, the instructor used the SMARTBoard a lot and he used the clickers in his work. And the kids loved it, like they were, as soon as say, 'okay, it's clicker time', they were like "Yay"*."

> "*I think, kids would love to use clickers, cause it's very hands-on, you get press buttons, right? Yeah, it's fun that way…Kids are pretty smart, a lot of kids are pretty good at technology.*"

Also, in response to survey item #27, "My interest in implementing technology in my future classroom was increased because of clicker use", 67% agreed or strongly agreed, 27% kept neutral, and 7% disagreed.

The majority student interviewees (80%) indicated a preference to use clickers as an assessment tool in their future teaching, and two of them came up with innovative instructional strategy. For instance, "*having the kids write a 140-character review of a character that they read in a book*", or "*linking the response system to iPad or Smartboard, and having kids draw their answers*".

Feedback from student interviews and from the student survey indicated that the majority of those who were interviewed or surveyed were excited about incorporating clicker technology in their future teaching.

From the multiple sources of evidence, one can claim that the majority of students who participated in the study and the instructor were satisfied and excited about the clicker use in the plenary. However, beyond the overall good user experience of using clickers, one student interviewee commented that although he agreed that the clicker technology could play a significant role in helping to transform a passive learning environment to a more active one, it still has limitations on making a radical change of the lecture learning environment.

> *"I don't think it's going to be like a complete revolution as how we share and communicate ideas with each other…I don't see that could be like any massive improvements on the use of clicker based on just its simple applications.*"

Additionally, the ten interviewees gave valuable advice on how to make full use of the potentials of clicker technology to support active learning and knowledge building in classroom. In the next section, the recommendations from students and the instructor on how clickers can and should be used for learning are summarized.

Future Use

Opening Remarks on Future Use

The unique research participants, pre-service teachers, and the instructor contributed their thoughtful insights on how to improve instructional and technological use of clickers to better support active learning and knowledge building in large lectures in higher education, and also in K-12 classrooms.

Three of the ten interviewees expressed that this hands-on experience of clicker use intrigued them to think more about effective ways of using clickers with their own students. One student said that:

> "*Using the technology in different ways or new ways, I think is important. And it gives you an idea of what you might be able to do in your own classroom...How can I apply this to my teaching? What could I, how could I use this to engage my students in my teaching?*"

Effective Instructional Use

The instructor believed that it is crucial to develop some effective instructional strategies of clicker use to engage students. S/he said:

> *"You don't want the technology to just be a cute add-on, a fun kind of add-on, you really want to use it to more deeply engage the students in that class."*

Two student interviewees generated a point that in future use of clickers, educators should make sure that the clicker use is serving the purpose of actually engaging students in their learning. The extent to which the use of clickers could engage students greatly depends on the quality of instructional strategies. One student argued that the use of clickers should be productive in classrooms rather than just be a trend to use it, and s/he said:

> "*Making sure that the students are actively participating in school and are able to actually learn and take advantage of their education, rather than just for the sake of having the technology there.*"

Feedback from student interviews and instructor interview indicated that the instructional strategies regarding clicker use may influence the level of student engagement in class. The student interviewees further pointed that if better clicker questions were asked and more discussion around the clicker questions were facilitated, they would be more engaged in learning.

Quality of Clicker Questions

Four student interviewees agreed that the extent to which active learning and knowledge building may be supported by clicker use depends on the quality of clicker questions being asked.

> *"I think, how thoughtful they are making up the question is important. Like the, really the kind of question that they are asking will either result in more active engagement, like they just throw out a fact or something, the question wouldn't have much meaning. So how you frame a question is really important to how you are going to engage the people in the lecture."*

Five students commented on what kinds of clicker questions might effectively engage students in their leaning (see Table 4.5)

Table 4.5 Suggestions on the Design of Clicker Questions

Suggestions	Quotations
Ask more critical questions (one student indicated)	--*"But it's actually more critical a question…then find that's more active learning happens."*
Ask questions that are related to the course material in a deeper level (two students indicated)	-- *"There wasn't really a feeling like we were being asked to engage with the course material in deeper level."* --*"If you are not engaged with what you are doing (learning), then having different tools isn't going to make it more fun or more interactive."*
Ask more questions with different question types (four students indicated)	--"*Or even having more, I mean most lectures we only had one question that we did, but we could see if you integrated it a bit more into the lecture too, then that would engage people throughout the lecture, could have different kinds of responses.*" --"*If there was a more of an intensive use of the clickers that served a greater purpose…there could be more hands-on activity, there would be more community building.*"

Besides, the instructor commented that asking various types of clicker questions can be helpful to increase student engagement both in large lectures and small classes. S/he said:

> "*Because whether you have a group of 30 students or whether you have a group of 400, you are still going to have diversity of learning styles and participatory styles…and different types of questions were sensitive to the different leaning and participatory styles of the students in the class.*"

As analyzed earlier, some students reported that they enjoyed open-response questions, some students indicated preference for multiple-choice questions, and still other students might like other question types. Therefore, asking different types of clicker questions can accommodate diverse learning needs and potentially engage even more students.

The instructor demonstrated his/her preference for open-response questions from the perspective of how it supports teaching.

> *"The narrative type questions and responses gave a more holistic representation of students' experiences and perspectives. And by looking at what the students texted, I was able to make links and bridge one response with another, and I was also able to see some dominate themes that emerge out of the narrative responses, whereas in the 'true or false' and the multiple-choice, the graphs show individual sections, so things are quite fragmented, it breaks the responses into individual pieces, then narrative responses connected the pieces and showed more about the relationship.*"

Although the instructor thought that the text-entry questions and responses helped to carry out his/her role as an instructor, and the majority of students believed that the text-entry questions and responses helped them collaboratively build knowledge, the instructor and half of the student interviewees (50%) all indicated that they spent quite a long time waiting for all the students to respond to an open-response question. Some students entered their responses quickly, while some students needed more time. One student further claimed that if they did not have to wait for so long, they might feel more active learning and more knowledge building. In addition, two students from a focus group had some discussion on how to deal with the long response time:

> Student A: "*Maybe perhaps giving a time limit, like 'okay, everyone respond within the next two minutes'*."
>
> Student B: "*Because there is going to be those students that need that processing time. And if they feel that pressure right away to respond, especially with a written response, you might actually shut them out, they might not respond at all, or not really respond how they want to respond to*."
>
> Student B: "*Just giving some time, maybe bring up the question at the very beginning of the lecture, and then having the students kind of process it, think about it, and then continually along with the lecture…and bring it up again (later) as people have something to write about, so the answer would come quicker.*"
>
> Student A: "*I really like that idea.*"
>
> Student B: "*Yeah, trying to make it smooth of the transition throughout the lecture as you could without being kind of disruption (long response time).*"

Therefore, adding the processing time of text-entry responses in the overall lecture plan could accommodate diverse learning needs, support and encourage more students to contribute their thoughts. One student and the instructor also asked for the possibility of having the responses coming up on screen as students post it in order to shorten the waiting time, and to give students something to reflect on while waiting for all to respond.

Besides using clickers as a tool for students to respond to questions prepared by the instructor, two students suggested that the clickers be used as a tool for inquiry. For instance, students could post their own concerns or struggles with course concepts, or post their own learning interests and questions. In this way, students could be more engaged in their own learning, and the instructor could make better decisions about where the plenary is going and could prepare better lesson plan addressing students' concerns or struggles and meeting students' diverse learning interests.

Based on the feedback gathered from student interviews and the instructor interview, it can be summarized that if the clicker questions could be designed to provoke more critical thinking or be related to the course materials (e.g., readings) in a more profound way, if more clicker questions with different question types could be asked, and if students could post their own questions, concerns or interests by using clickers, then there may be even more potential for greater student engagement in active learning and knowledge building in the large lecture.

Facilitation of Discussion

The majority of student interviewees (90%) expressed the desire for more discussion after seeing the clicker question responses to gain an opportunity to actively reflect on and go into depth of the questions, student's own answers and their peer's answers, to have some idea exchange, and to build or improve their learning collaboratively. Two students reported that the discussion could be like this:

> "*Hey, you know, I thought about person No.3, their answer was really interesting, or oh, my answer was No.8, and I wrote that because…*"

> "*So that when you discuss, like 'I thought in this way, I thought in that way', that's where you started building your understanding.*"

The instructor also agreed that having more follow-up discussion would be helpful for student learning. Direct quote from the instructor is:

> *"One of the things that I learned from this experience is that I need to attend more to the discussion after the clicker data is posted. I think it's really important to integrate that discussion deeply into the session, and that's how the use of clickers supports learning."*

Six student interviewees contributed an important opinion that the discussion could be facilitated by the instructor by picking up one or a few interesting responses and asking one or a few follow-up question to gauge students' elaboration or expansion on their responses, or gauge

students' extra interpretation of their responses from the perspective of a future teacher. The possible follow-up questions expressed by students during interviews are depicted in Figure 4.4.

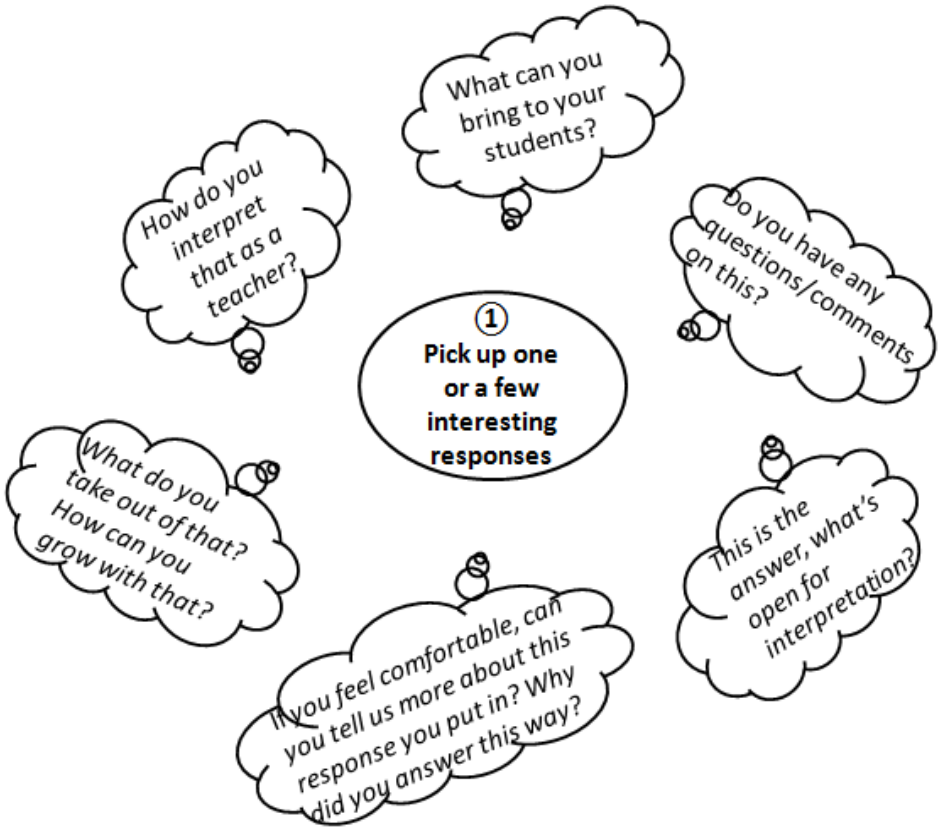

Figure 4.4 Follow-up Questions that Lead to Discussion

Two students also suggested that the instructor ask a follow up question towards the theme generated from all the responses. One student provided more details:

> *"Like the question was, 'why are you becoming a teacher?', and the theme is, 'because I want to make difference in the world'. That's probably a big theme, so let's talk about that. How do you want to make a difference in the world? How will you make a difference? Where do you think you can start? How big a difference? When you make this difference?*"

The student further contributed an innovative idea that the textual responses might be linked to *Wordle* to see what words were most frequently used, and then to find the theme.

Some student interviewees offered additional suggestions on how the discussion could be facilitated:

- Posting the clicker question responses on the course Blackboard site, which may lead to ongoing discussion online.
- Starting with a general clicker question, a broader discussion may be facilitated; starting with a specific question, the discussion may be limited.
- A small group discussion with two or three people may be better than a class-wide discussion, because everyone can have a voice rather than a few people dominate the discussion.

The instructor also pointed out a useful strategy to gather group response and facilitate group discussion by clicker use:

> "*I could see it being really valuable in working with, you know, breaking a class into a number of small groups so that each group had a clicker, and they would summarize what went on in their small group at the end of their activity on the clicker technology.*"

Both the student and the instructor interviews have helped develop the understanding that it would be helpful for student learning to have more discussions either in small groups or on the course Blackboard site after seeing the question responses or after the plenary. The discussion can be initiated by the instructor through asking follow-up questions towards interesting responses or around the theme generated from the responses.

Value of Professional Development

The instructor stated the importance of exposing teachers to a new technology before implementing it in classroom. In this way, the instructor could gain some learning on effective

instructional strategies regarding the new technology. The instructor elaborated his/her thoughts as:

> *"I think it's really important that a lecturer has an understanding of how clicker technology can authentically contribute to engaged learning environment, otherwise it just becomes another shiny piece of technology that doesn't add value…I think it's really important that a lecturer never ask students to do something that they haven't tried themselves.*"

The instructor also made some suggestions on how to conduct teacher's professional development on clicker use:

- Have a one-hour or two-hour professional development session, from which the instructor can gain a hands-on experience on clicker use.
- Read some articles and learn from other teachers or researchers' experiences, in which the instructor can benefit from examples of successful instructional strategies and effective clicker questions.

One student interviewee also addressed that professional development of effective clicker use is important for teachers:

> *"I think you need to make sure that the teacher is familiar enough and comfortable enough with the technology if that's the direction the students are moving in, and that's something they can embrace and can encourage...If you are not giving the instructor a chance to get intimately involved in this piece of technology, then they are not going to know the most effective way to use it.*"

Therefore, we can foresee the value of exposing pre-service teachers to clicker use in their education if they would like to use clickers in their future classroom. One student commented on the value of using clickers in this plenary as:

> "*I think it's understanding and getting a hands-on experience…Like a lot of classrooms were technology, but it's kind of hard to use it if you don't know how to use it, kind of hard to use it like effectively in the classroom…So it's definitely helpful to actually hold on and see it…like whatever classroom I end up in, at least having used them as a student, it will*

definitely help me like understand kind of more the benefits they might get out of there, what ways like better to use it maybe than others."

One student further indicated that although it takes time to practice and get used to a new technology, as a profession we appreciate courageous teachers who are willing to be challenged and to try new technologies.

Feedback from student interviews and the instructor interview has helped to develop the understanding that professional development is necessary and crucial for teachers to gain an understanding of effective instructional use of clickers in order to create a more engaged learning environment for their own students.

The analysis of various responses indicates that the quality of clicker questions and the level of discussion around the questions may influence student engagement in the plenary. Therefore, it is valuable for teachers to have professional development on effective instructional use of clickers, for example, how to create engaging clicker questions and how to facilitate interactive and thought-provoking discussions. Further, having a hands-on experience of clicker use provides a professional development opportunity to the pre-service teachers, and these student teachers contributed a lot of insights on how to improve instructional clicker use.

Technological Support and Improvement

Besides the improvement of instructional clicker use, the technological aspects of the clicker technology and the provided technological support should also be improved to better support the instructional and learning needs. During the interviews, four students gave some advice on how to improve the technological aspects of clickers:

- Link the response system to Smartboard, which works as a back channel, and student responses show up on the board as they post it.

- Have a full screen and bigger font of the textual responses so that everyone can see it clearly. The instructor also advised that the textual responses be captured across the entire screen.
- Show everyone's response on individual clickers.
- Have a type of touch-screen clicker for users to choose, which may be easier for some students to text than using the keyboard.

In addition, the researcher suggested adding an auto-saving function to the SMART Notebook software to secure the clicker question responses in case that the data would get lost due to unexpected reasons. For example, during one lecture, the data was lost for one clicker question because of an accidental shut down of the computer.

The instructor demonstrated that technology support and personnel support was needed to successfully run the clicker technology in classrooms.

First, it is important to ensure that each student has access to clickers. The instructor said,

> *"Like we only had 200 clickers, and for us that was okay, because our student numbers were lower. But if we are going to use clicker technology, then we need to have enough clickers for everybody that could be in that class, otherwise it gives some students that opportunity to engage and others not, so it's not inclusive.*"

One student implied that it would be a huge benefit that each student is supplied with a clicker if the teacher planned to use it, rather than be the student's initiative to buy, which may not be as inclusive as it could be. Especially in K-12 schools, the unequal accessibility of technology may separate kids who can bring it and who cannot, and those kids who cannot bring clickers may feel disconnected from the classroom community. The student also said,

> "*I have to say I enjoy for 408 that I don't have to buy a clicker and worry about all that. It was horrible I did that for one class back UBC (University of British Columbia), spent $90 on the clicker, and then at the end I couldn't even sell it back because they updated the technology, so it was obsolete … So I was very happy when you came with your box of clickers … you don't have to put down payment on it or anything, you just pick it up and put it back, that was wonderful.*"

Then, the instructor mentioned several points that need attention when implementing new technology in classroom:

- The new technology does not interfere with the technology being used
- Have a robust platform that can effectively handle all the technology simultaneously
- Have a back-up system "*so that if one system goes down, the other still running*"
- Have resource people or teaching assistants there to help operate the technology

Interview feedback from students and the instructor indicates that some improvements on technological aspects of clickers can be made by having an easier access and adding an auto-saving function to the clicker question responses, making sure that clickers are available to each student, and by establishing a robust platform to support the clicker use.

Attractions of Attending Lectures

Due to the relatively low attendance rate which may be related to the recordings of lectures being made available, students articulated several factors that would attract them to attend the lecture.

1. The clicker technology is one draw to get people to come (four students indicated).

> "*And I would say probably, it was enough to balance off the fact that it was 5:30 lecture, so instead of going home and listening to ProfCast lecture I could do tonight, I rather go for the lecture and be somewhat involved in the clickers and get different opinions.*"

However, almost half of the students (47%) disagree or strongly disagree with survey item

#3, “My attendance in lectures was increased because of the clicker use”.

“It’s hard when the lectures are recorded and put online, it makes it hard to come to class sometimes even if there is clicker technology to use.”

2. Interesting and valuable learning content beyond the textbook (four students indicated).

“*I want to hear something different in a lecture, I want to either cover different material or present it in a different way, or I want it expanded on or I want it challenged.*”

3. A good instructor, who is knowledgeable, enthusiastic, and engaging (30%).

“All the professors have just said, ‘×× is doing a guest speech thing’, and everyone shows up, because everyone knows it, he is passionate, he is a wonderful speaker, he is a performer, he engages his audience, he has this specific nature about him when he’s speaking…he has this wonderful balance of being playful but also really getting into the point and heading the point hard.”

4. A wide range of guest speakers (20%).

“*Because there’s something different and new, and maybe new information would be brought in that I don’t have access to through the readings that being assigned or the videos.*”

Concluding Remarks on Future Use

Suggestions on clicker use presented in this section, including the need for more effective clicker questions, facilitated peer-to-peer and whole group discussion associated with clicker questions, teacher’s professional development, and the need of sufficient technical support, all of which enriches our understanding towards the improvement of clicker use, and direct our future practices.

Conclusion

This chapter presents an analysis of data collected in this study from multiple sources of evidence, including classroom observations, student interviews, the instructor interview, student survey, clicker question examples and responses. The triangulated data analysis presents a more

holistic view of the participants' experience with clicker use in this large lecture. Major findings emerged from the analysis of data, recommendations for future clicker use and research practice, and the significance of this case study are discussed in Chapter 5.

CHAPTER 5 DISCUSSION, RECOMMENDATIONS, AND CONCLUSION

The majority of previous studies regarding the use of audience response systems in higher education were completed in natural science disciplines, and relatively little of the research on clicker use was done with education undergraduate students (i.e., pre-service teachers). To address the gap in the research literature, a case study using mixed methods of data collection and analysis has been employed to explore and document these student teachers' unique perspectives on the ways and extent to which the use of clickers could support active learning, and go beyond that to support knowledge building in large lectures.

Discussion of Major Findings

This case study examined the use of clickers by student teachers in a large lecture learning environment. The major findings from this study will be presented in three sections, each of which is a response to each of the three research questions.

Active Learning

The first research question that this case study aimed to address was: In what ways and to what extent does the use of clickers in large undergraduate lectures engage pre-service teachers in active learning?

Previous research (Bonwell & Eison, 1991; Chickering & Ehrmann, 1996; Michael, 2006) has identified and summarized several characteristics of an active learning environment, such as students' higher engagement in various activities that contribute to their learning, students' increased motivation to learn, and so on. Findings from this case study build and extend upon previous research findings regarding the use of clickers to promote active learning in large lectures (Albon & Jewels, 2007; Martyn, 2007; Mollborn and Hoekstra, 2010; Murphy & Smark, 2006b; Nagy-Shadman & Desrochers, 2008), and indicate that with the implementation of

audience response systems, characteristics of active learning were found in this large lecture setting where those student teachers were actively involved in their learning. Details on how the use of clickers can interrupt passive learning and build up active learning experiences in large lectures are summarized and discussed in the following sections. Some of the findings from this study confirm findings from previous studies, and the majority of the present findings are in partial confirmation of previous studies and are provided with further analyses and suggestions in the *Effective Instructional Strategies* section and the *Recommendations* section.

Attention

Findings from this case study indicate that the use of clickers can support student teachers in active learning by alleviating the boredom students might experience in passive lecture environments, by keeping students focused on their learning through participating in clicker-based activities, and thus laying a foundation for active learning to occur. Midderndorf and Kalish (1996) state that adult learners' attention span in a lecture is usually around 15-20 minutes, so periodic activities as a 'change-up' are needed in classes to restart the attention clock. In traditional lectures where the instructor dominates the talking and students passively listen to the instructor, students may easily lose their attention. Similar to Caldwell's (2007) findings about the link between clicker use and attention span, findings from this study suggest that these periodic activities initiated by clicker use, such as responding to clicker questions and reflecting on individual and the group's responses, can draw students' attention to the concepts and ideas presented in a large lecture, and can lead to students' active learning of those presented concepts.

Participation

Findings from this case study indicate that the use of clickers can support student teachers in active learning by increasing students' participation in large lectures, even though students' participation in this study was only slightly increased by the implementation of clickers. In traditional lectures, students tend to sit quietly in the classroom, passively listen to the instructor and take notes on what they are forced to listen to during lecture. By answering clicker questions, contributing their individual thoughts, and accessing the group's responses, students can gain more opportunities to participate in lectures. Especially in lectures with a large group of students, each learner can have an equal voice with a clicker in their hands. Based on the increased participation, the majority of student participants in this study felt that they were more involved in being part of the lecture. Cacciamani, Cesareni, Martini, Ferrini, and Fujita (2012) found that a higher level of student participation is conducive for students' learning of better quality. It can be commented that student's higher participation brought by clicker-based activities can lead to student's active learning in large lectures. When students actually participate in diverse learning tasks they can be more actively engaged in attaining and improving knowledge.

Instant Feedback

Findings from this case study indicate that the use of clickers can support student teachers in active learning by providing students with instant access to the whole class's responses to clicker questions. As suggested by previous research on the value of instant feedback (Hoekstra, 2008; Johnson & Lillis, 2012; Murphy & Smark, 2006a; Sprague & Dahl, 2010), findings from this study also indicate that the instant responses to clicker questions displayed on screen is valuable to direct learning and teaching. Especially with the immediate access to open-ended textual responses, students can have the opportunity to learn from the diverse mindsets and

perspectives of their peers, which is usually missing in lectures with a large group of students who sit beside each other and rarely discuss the course content. The instant feedback, or access to the group's response to a clicker question, is important because it gives students and the instructor access to the group's thinking for further discussion, analysis, and reflection. The instructor can immediately display the bar chart or range of textual responses to the group to provide information to guide peer discussion and also to inform a whole group discussion.

Interaction

Findings from this case study indicate that the use of clickers can support student teachers in active learning by promoting peer interaction, even though the interaction in this study was promoted only in a slight way. Findings from the present study are similar to what previous research found on promoting interaction with clicker use (Johnson & Lillis, 2010; Kaleta & Joosten, 2007; Martyn 2007; Nagy-Shadman & Desrochers, 2008). In large lectures, students traditionally sit together and have little or no interaction with each other about the course topics. With the clicker use, the silent mode of a traditional lecture can be broken by initiating students' bigger dialogues about the clicker questions and responses. In this case study, even though students had few opportunities to actually talk to each other and to discuss their responses to clicker questions, students could still be engaged to interact with different perspectives and have an idea exchange by reflecting on their own and the group's diverse responses displayed on the screen, which may help students to actively improve individual and the group's learning. Findings from participants in this study also suggest that the level and quality of student's interaction and active learning in large lectures can benefit from having more discussion around the clicker questions and student responses, details of which will be discussed in the *Effective Instructional Strategies* and the *Recommendations* section.

Reflection

Findings from this case study indicate that the use of clickers can support student teachers in active learning by offering students more opportunities to reflect on their learning and thinking. In traditional lectures, students are recipients of information and have few opportunities to reflect on what they have learned. By responding to the clicker questions, students can be engaged to actively process, internalize, and evaluate the information or ideas shared during lecture time, to choose their stance towards certain opinions, and to generate their new understanding or interpretation towards certain concepts. This reflection process can develop and apply student's higher-order thinking skills (Anderson & Krathwohl, 2001), such as analysis, evaluation, and creation. Especially with the use of text-entry clicker questions, students are enabled to actively build and extend upon their existing knowledge, and to generate and articulate a concise reflection of their learning.

For this study, it can be argued that the use of clickers can break up the passive learning environment in conventional large lectures that are lead by the instructor, and can add those active learning characteristics into the large lecture setting and help students to actively attain knowledge. As Scardamalia et al. (2012) state that active learning is the entry-level of an knowledge building environment, it can be demonstrated that in this case study, an active lecture environment has been established by the use of clickers and has laid a solid foundation for the occurrence of student's deeper learning, such as knowledge building.

Knowledge Building

The second research question that the case study aimed to address was: In what ways and to what extent does the use of clickers in large undergraduate lectures engage pre-service teachers in knowledge building?

Drawing upon the definition of knowledge building (Scardamalia & Bereiter, 2010), which is collaborative creation and improvement of knowledge that has value to the community, it can be concluded from this study that the clicker technology can be used to support a large group of students in lectures to collaboratively create, share and slightly improve their knowledge as a learning community, especially when students are involved in responding to the open-response questions in an anonymous way. Further, the opportunity to collaboratively build knowledge is usually missing in either large lectures or small classes that focus on information delivery.

Creation

Through answering the open-response text-entry clicker questions, students can be engaged in reflecting on their learning, organizing their thoughts, identifying essential points and selecting key words to create new ideas based on their existing knowledge. In traditional lectures, students have few opportunities to create their own knowledge. In the twelve knowledge building principles, Scardamalia and Bereiter (2010) address that knowledge building usually arises from the pursuit of real ideas, from the understanding and solving of authentic problems, and from the constructive use of authoritative information. For this study, evidence collected from classroom observations, clicker question examples and student responses indicate that ideas generated from some of the clicker question responses were based on students' real-life experiences that had contributed to their developing understanding of their role as a teacher and of themselves. For example, the instructor asked one question during a lecture, "Share a lifelong learning moment that has contributed to you arriving at this place and time (becoming a teacher)". One student answered, "*I had an awesome teacher in high school that I strived to emulate. If I hadn't been in his class, I wouldn't have decided to become a teacher*". Some of the clicker questions also encouraged students to build their own interpretations of learning concepts

and to question the authoritative information. For example, the instructor asked one question during a lecture, “What does lifelong learning mean to you?”. So, depending on the pedagogical purpose of each clicker question, the clicker technology can be used to support students in building new knowledge based on student’s deep reflection upon their real-life experiences, existing knowledge, and authoritative information presented during the lecture time.

Sharing

Immediate access to students’ diverse responses to clicker questions, especially in textual format, supports *idea diversity* (Scardamalia & Bereiter, 2010) and provides students with an opportunity to share individual knowledge and to build it as a ‘*community knowledge*’ (Scardamalia, 2002). It is challenging to generate the community knowledge in lectures of any size. Diverse perspectives were generated and supported by responding to the open-ended questions using clickers. Each student has the opportunity to interpret and respond to a clicker question differently, based on the students’ varying education backgrounds, life experiences, and the use of vocabulary. In this study, the majority of student participants indicated that they appreciated and valued the deep and rich sharing of diverse ideas because they could learn from each other’s brilliant, intriguing, and unique ideas that lead to the production of community knowledge. Scardamalia et al. (2012) state that community knowledge does not just reside in the minds of individuals but is available for others to build on and improve. In this study, it can be documented that the use of clickers does provide students in the large lecture with a platform to make individual opinions public and to share the diverse opinions as community knowledge, upon which students can build and improve their learning.

Improvement

Scardamalia et al. (2012) indicate that improvable ideas emerge as the ideas are entered into communal space where the idea contributors can continually work on these ideas. In this study, the knowledge builders (i.e., student teachers) first set forth individual ideas by responding to clicker questions, and the immediate responses displayed on screen allows students to advance their learning. Feedback from student interviews indicate that by critically reflecting on the group's response displayed on the screen, for example, by contrasting or combining individual responses with the group's response, students would be given the chance to enhance their individual perspectives, broaden their views, change their opinions, and come up with new ideas. So, in this case study some limited but promising evidence has been found on knowledge improvement with the use of clickers. In this study, students were given few opportunities to discuss, build and extend upon the group responses in peer-to-peer discussion after the display of results. It is hypothesized that there could be more evidence of idea improvement if more time and opportunity for peer-to-peer discussion was added to the lecture plan. Scardamalia and Bereiter (2010) suggest that knowledge itself can be advanced through discursive practices within a learning community, which implies that students might benefit from open discussion associated with clicker questions and the group's responses. In the discussion, students could gain more opportunities to work collaboratively with diverse ideas and to go beyond their initial ideas and conversations to achieve new syntheses. Details on how to facilitate the discussion is presented in the *Effective Instructional Strategies* section and *Recommendations* section.

Learning Community

In this study, with the use of clicker questions and the immediate access to student responses, student teachers, the instructor, and the course content were more connected as a learning community (see Figure 4.3). Further, the anonymous nature of clickers provides learners with a psychologically safe environment that allows and encourages everyone in a large lecture setting to take part in creating, sharing and improving individual and the group's ideas as a learning community. More specifically, the use of clickers gives each learner an equal opportunity to contribute individual ideas by responding to clicker questions, especially for learners who are introverted or are less inclined to speak up in a large group. Having the anonymous clickers, students feel safer being open to express and share their true opinions, and have less risks giving and receiving the types of criticisms and comments that might be beneficial for idea improvement. As a result, *democratizing knowledge* (Scardamalia & Bereiter, 2010) can be produced, in which every learner is a contributor to knowledge building.

For this study, it can be argued that the use of clickers can help to move up students from surface learning to deeper learning, in this case, collaborative knowledge building. In the next section, strategies on using clickers to better promote student's learning are summarized.

Effective Instructional Strategies

The third research question that this case study aimed to address was: What are some of the effective instructional strategies regarding clicker use that can better engage students in active learning and knowledge building in large undergraduate lectures?

Similar to previous research findings (Bruff, 2007, 2009, 2010) on effective clicker use, findings from the present study also indicate that the effectiveness of using clickers to support active leaning and knowledge building in large lectures depends largely on how the instructor

uses and manages the system, from the types of questions they ask to the ways that clickers are used to structure discussions and manage classroom activities. The effectiveness of clicker use also depends on the technological support provided in order to facilitate classroom learning activities. In this study, student teachers provided suggestions on the possible ways to improve instructional and technological use of clickers from both the perspectives as learners and as future teachers. The instructor also offered hands-on experiences regarding how to utilize the clickers to better serve learning and teaching purposes.

Effective Question Design

The commonly used clicker pedagogy is called "question-driven instruction" (Beatty et al., 2006), an approach that teachers prepare several clicker questions and ask students to contribute their responses in class. Findings from this study suggest that the content and type of clicker questions and the frequency of asking clicker questions are some of the factors that impact the effectiveness and quality of learning with clickers.

Interview feedback gathered from this study suggests that students might be more engaged in their learning by responding to clicker questions that have the potential to provoke student's more critical thinking and deeper reflection on the learning materials. Interview feedback also suggests that asking clicker questions of various types (i.e., text-entry, multiple-choice, yes or no, true or false, etc.) in a greater volume might accommodate diverse learning demands and engage more learners in active learning and knowledge building. Nelson and Hauck (2008) found out that the greater the volume of clicker usage was, the more favorable student perceptions were in terms of learning motivation. Given the fact that only one clicker question was asked in most of the lectures in this study, students' learning motivation and participation level was found to be only slightly increased as indicated by the student survey responses.

Having a higher frequency of clicker use, such as incorporating more clicker questions in each lecture, and more question types, student's participation/contribution during lecture time and their motivation to learn both inside and outside of the lecture time might be increased.

Another important finding in this study is that the open-response text-entry questions are regarded by students as an effective and successful clicker question format to serve the goal of supporting learners in collaborative knowledge building. The text-entry questions and the immediate responses provided students with more possibilities to create individual ideas, link and bridge individual ideas to the group's ideas, think beyond individual positions and beliefs, and therefore to advance individual and the group's learning.

Thoughtful clicker questions can lead to thoughtful discussion. The next section illustrates the ways in which the discussion related to clicker questions can be facilitated to engage students in their deep learning.

Facilitated Discussion

Previous research (Beatty et al., 2006; Beekes, 2006) has found that well-organized discussion can promote student learning by stimulating and encouraging students to have an in-depth exchange and a richer dialogue about each other's unique ideas, opinions, and beliefs. Thomas and Brown (2011) articulate that interaction among group members, with their varying skills, talents and ideas, functions as a kind of peer amplifier, providing numerous outlets, resources and aid to further both individual's and group's learning. However, productive discussions that can be associated with the clicker use were almost missing in this case study. Those pre-service teachers claimed that peer discussion or group discussion related to the clicker questions and student responses would be valuable to the advancement of community knowledge and could be facilitated more often by the instructor.

Cognitively high-levels of discussion are led by well-constructed clicker questions (Marlow et al., 2009; Skinner, 2009). In this case study, as these pre-service teachers suggested, discussion can be initiated by the instructor by asking follow-up questions (see Figure 4.4) raised from interesting question responses submitted by individuals, or from the big theme generated from the group's responses. Discussion can be started by asking a second question that leads into deep discussion about the content of first question. For example, there was a good question example in this case study. One multiple-choice question asked by the instructor was, "Where do we locate ourselves? What informs our philosophy of education, teaching, and learning?", and students were invited to choose one option from "Liberal, Behaviorist, Progressive, Humanistic, and Radical". After students sent their responses, the instructor asked another question, which was "As a teacher/educator, and from where you have philosophically located yourself, how might you respond to the issue that all Albertans are mandated to adjust to a vegetarian diet by January 1st, 2013". Then, several students described how s/he would organize discussions around this issue with their own students using different teaching philosophies. Through this class-wide discussion, students were engaged in in-depth understanding and instant application of those teaching philosophies.

By having more opportunities to confront and work with diverse ideas through questioning and discussion, the level of students' participation, peer interaction, and student-instructor interaction could be greater promoted. By integrating more discussion with clicker use, students can feel more a part of a learning community where the community members work collaboratively to improve their learning. Findings from this study further indicated that the number of students present in the lecture and how closely the students sit together in a large lecture hall are factors that can impact the level and quality of discussion.

In this section, major findings on the ways and extent to which the use of clickers in large undergraduate lectures engaged pre-service teachers in active learning and knowledge building, and on the effective instructional strategies that can be employed to facilitate achieving both of the learning goals were presented. In next section, recommendations generated from the research findings are discussed.

Recommendations

Lessons learned from this case study and suggestions provided for future teaching and research practice on clicker use are summarized in the following sections.

Recommendations for Clicker Use

Several recommendations for instructional clicker use are presented in this section, including: focus on the pedagogical objective of each clicker question, solution to the long waiting time for answering text-entry clicker questions, innovative clicker use for knowledge building, strategies of using clickers to promote student's learning motivation, and the value of professional development and technical support.

As every clicker question can serve an explicit learning objective (Beatty et al., 2006; Caldwell, 2007; Skinner, 2009), it can be stated that how students perceive the benefits that clicker questions bring to their learning depends on the pedagogical objective of each question. In order to achieve the learning objectives of a course, the content of each clicker question should be closely related to the focus of each lecture. For example, as suggested in the Literature Review, in order to engage students in knowledge building, clicker questions should be designed to make connections to *real ideas and authentic problems*, direct students to practice the *constructive use of authoritative sources*, support the occurrence of *improvable ideas* and *idea diversity*, and to provoke students' higher-order thinking and peer-to-peer discussion. In order to

achieve the learning objectives of a course, the type of clicker questions should support that learning objective. For example, in this study, the open-response text-entry clicker question that can gauge students' holistic perspectives and initiate in-depth discussion about certain topics or issues has been found as a supportive question format in a knowledge building classroom.

As one solution to the relatively long time (i.e., at least five minutes) spent in waiting for all students to respond to text-entry questions, it is suggested to add a time limit to each question (e.g., two minutes). In this study, from the duration time documented by the SMART Notebook software when students were answering the first text-entry question, one can observe that the average response time was only two minutes. As students were getting familiar with the clicker technology and with the text-entry question type, the response time should be shortened instead of getting longer, so two-minute response time could be enough for a text-entry question.

In addition to the teacher designing clicker questions for instructional use, students can be better engaged in their learning by designing their own clicker questions. As question design usually requires student's creativity and critical thinking skill, there is an opportunity to explore how the activity of having students create their own clicker questions either as an individual or a group contributes to collaborative knowledge building. Also, the instructor can ask students to post their individual learning interests, questions or concerns towards course concepts via using the clicker, which can potentially address students' diverse needs and guide the instructional plan.

To maximize the potential of using clickers to support knowledge improvement, peer discussion or class-wide discussion facilitated by the instructor can and should be incorporated into large lectures. It is suggested that discussion take place after students send their responses to clicker questions, or after students gain access to their own and the group's responses, as

knowledge advancement happens only if learners have developed and considered their own initial ideas. Discussion can be facilitated by distributing students into several small groups and having students contribute a negotiated and agreed response to the clicker question as a group. Discussion can also be initiated by posting all the question responses in communal space (e.g., course Blackboard site) after each lecture ends, then students can have a deeper and rich dialogue around the clicker questions. In this way, a communication platform can be created for these knowledge contributors to continually improve the community knowledge.

For future practice, considerations should be also put into the development of sound instructional strategies regarding clicker use that can be employed to promote student's learning motivation. Survey responses collected in this study revealed that the use of clickers did not bring as much learning motivation to students as expected. In future practices, emphasis should be put on designing clicker-based activities that have the potential to simulate student's learning motivation. For example, those clicker-based activities can include responding to clicker questions that can stimulate student's interest to do more readings/research, gather more information, and have more conversations around new learning content.

In addition, it can be documented that teacher's professional development on the operation of clicker technology, and more importantly, on the effective pedagogies of clicker use that can better engage students in their learning is recommended when incorporating clicker technology into lectures. A robust technological platform and available technicians are necessary to guarantee the smooth operation of clicker technology in lectures.

Recommendations for Research

Several recommendations for research on clicker use are presented in this section, including conducting a multiple-case study or a longitudinal study, having a larger research/survey sample, and observing the research site as a participant observer.

This single case study has been proved to be an effective and successful research design, as it has provided a representative case to inform our understanding about student teachers' average experience on clicker use in large lectures. However, Yin (2009) addresses that a common concern of case studies is that they provide limited basis for scientific generalization. "In fact, scientific facts are rarely based on single experiment; they are usually based on a multiple set of experiments that have replicated the same phenomenon under different conditions" (Yin, 2009, p.15). In order to provide more generalization of the research findings, a multiple-case study design that studies the use of clickers with multiple class groups that have more complex and distinctive learning, participatory, and instructional styles associated with clickers is recommended for future research.

The findings of this case study are based on limited use of clickers in only seven lectures and one clicker question in each lecture. The impact of clicker use on student's active learning and knowledge building might be different if the clicker technology was used on a more frequent basis and in a longer term. A longitudinal study with more intensive clicker use, for example, implementing clickers in several different plenary series that have the same student group in one academic year, might generate more meaningful and generalizable findings.

This case study was conducted in recorded lectures. Recorded lectures meant that there were few students in each lecture, and so students sat apart throughout the large lecture hall which limited the opportunity for students to interact and discuss ideas with each other. It is

recommended that future research which intends to explore the benefits of using clickers in large lectures would be better conducted in lectures with at least fifty or more students being present.

Within the accessible research population, this case study got a sufficient student interview sample (n=10), but the student survey sample is small (n=15), which is far from the expected sample for a survey. However, triangulation of evidence collected in this study from classroom observations, student interviews, the instructor interview, student survey, clicker question examples and student responses has contributed to a construction of solid and defensible findings. One can figure out that future research will benefit more from a larger student survey sample. In addition, survey method has its limitations that the researcher might miss out important survey items. For example, during data analysis of this study, the researcher realized that one student survey item regarding active learning should have been added, which is "*The use of clickers provided me opportunities to become a more active learner in large lectures*".

The researcher took her role as a non-participant observer when observing student's group behaviors linked to clicker use. Creswell (2012) claims that a participant observer can be offered with "excellent opportunities to see experiences from the views of participants" (p. 214) and can gather more concrete observational data than a non-participant observer. For future studies, it is recommended that the researcher act as a participant observer who actually engages in responding to clicker questions or taking part in other clicker-based activities to obtain a hands-on experience of the ways in which clicker use supports active learning and knowledge building in large lectures.

In this section, the recommendations for clicker use and research which can be beneficial for future learning, teaching, and research practices on clicker use in higher education, were presented. In the final section, the conclusions are presented.

Conclusion

Based on the findings summarized in this case study, it can be argued that the use of Audience Response System (i.e., clickers) can engage pre-services teachers to actively learn, create, share, and slightly improve their knowledge as individuals and as a community of learners. In this study, suggestions on clicker use have been generated to inform future teaching, learning, and research practices.

The interactive clicker technology is found to be closely matched to the demographics of today's student generation, the Net-Generation, who tends to be more inclined to actively learn in a participatory culture and to learn playfully with technologies. The open-ended text-entry clicker questions appear to meet the demands of today's educational shift in cultivating students who are in pursuit of new and improvable ideas/knowledge in order to embrace the rapidly changing world instead of developing students who are passively receiving existing knowledge or are only seeking right or wrong answers.

Findings from this study also suggest that the implementation of clickers in large lectures can offer a solution to the challenges that some instructors are facing with in creating an engaged learning environment for every student in a large lecture setting.

When utilizing educational technologies in classroom, it is important to make sure that those technologies are actually serving the purpose of engaging students in their learning. Findings from this study can inform instructors of effective instructional designs and course delivery approaches regarding using clickers to engage students in large undergraduate lectures, and can intrigue pre-service teachers to think about some of the effective and innovative ways of using clickers to engage their own students, the Millennials, in K-12 classrooms.

This case study expands the current knowledge base on the use of clickers in large undergraduate lectures by studying with pre-service teachers and by contributing insights on a new functionality of clickers, which is to support student's knowledge building. This research generates the potentials of encouraging faculty in higher education to design and deliver clicker-enhanced lectures to promote student's deeper learning and improve the quality of teaching across disciplines. More research is called upon to explore and develop innovative instructional use of clickers to engage students to collaboratively improve their learning in knowledge building environments.

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APPENDIX A CERTIFICATION OF INSTITUTIONAL ETHICS REVIEW

UNIVERSITY OF CALGARY

CERTIFICATION OF INSTITUTIONAL ETHICS REVIEW

This is to certify that the Conjoint Faculties Research Ethics Board at the University of Calgary has examined the following research proposal and found the proposed research involving human subjects to be in accordance with University of Calgary Guidelines and the Tri-Council Policy Statement on *"Ethical Conduct in Research Using Human Subjects"*. This form and accompanying letter constitute the Certification of Institutional Ethics Review.

File no:	**7045**
Applicant(s):	**Angyue Liu**
Department:	**Education, Faculty of**
Project Title:	**Exploring the Use of Clickers to Support Active Learning and Knowledge Building by Pre-Service Teachers in Large Lectures**
Sponsor (if applicable):	

Restrictions:

This Certification is subject to the following conditions:

1. Approval is granted only for the project and purposes described in the application.
2. Any modifications to the authorized protocol must be submitted to the Chair, Conjoint Faculties Research Ethics Board for approval.
3. A progress report must be submitted 12 months from the date of this Certification, and should provide the expected completion date for the project.
4. Written notification must be sent to the Board when the project is complete or terminated.

Kathleen Oberle

Kathleen Oberle, PhD
Chair
Conjoint Faculties Research Ethics Board

OCT 1 1 2011

Date:

Distribution: (1) Applicant, (2) Supervisor (if applicable), (3) Chair, Department/Faculty Research Ethics Committee, (4) Sponsor, (5) Conjoint Faculties Research Ethics Board (6) Research Services.

APPENDIX B STUDENT CONSENT FORM

Name of Researcher, Faculty, Department, Telephone & Email:

Angyue Liu, Faculty of Education, 403-970-7891, angliu@ucalgary.ca

Supervisor:

Dr. Michele Jacobsen, Faculty of Education

Title of Project:

Exploring the Use of Clickers to Support Active Learning and Knowledge Building by Pre-Service Teachers in Large Lectures

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Purpose of the Study:

You are being invited to participate in a research study related to the use of clickers by pre-service teachers in large lectures.
The goals of the research are to explore:

- The ways and extent of using clickers to engage and support pre-service teachers in active learning.
- The possible ways and extent of using clickers to engage and support pre-service teachers in knowledge building (i.e., collaborative creation and continual improvement of new knowledge).
- The benefits and challenges that students and the instructor have throughout the course with the use of clickers.

What Will I Be Asked To Do?

Tasks to do:

1. You are being invited to participate in a one-hour individual interview or focus group interview that will occur on campus outside of lecture time. Care will be taken by the researcher to protect the anonymity and confidentiality during interviews. Participants in focus group interviews will also be informed that a focus group cannot be completely anonymous, and will be asked to refrain from referring to each other's names during conversation and after the focus group as a measure to protect confidentiality.
2. You are being invited to complete an anonymous survey via the clicker devices during a regular lecture time upon the end of this course.
3. You will be informed when the researcher is present in lecture to collect observational data. During classroom observations, you will not be interrupted by the researcher, or identified in any way.

Your participation is complete voluntary. You can participate in all of the three tasks, some of them, or none of them. You have the right to withdraw from the research at any time after consenting, without

any penalty. No bonus points will be earned by participation. Also, participants' course grades will not be affected by participation, nonparticipation or withdrawal.

Dissemination of Findings:

The main use of collected data will be to inform a Masters Degree project that will result in a thesis. The final report may be published online or in print journals and may be presented at local, provincial, national or international academic conferences for the purposes of furthering an understanding of the use of clickers in large-lecture learning environments in higher education.

What Type of Personal Information Will Be Collected?

No personal identifying information will be collected in this study, and all participants will remain anonymous / confidential.

There are options for you to consider if you decide to take part in this research. You can choose all, some or none of them. Please put a check mark on the corresponding line(s) that outline your wish for consent.

1. I give informed consent to participate in a one-hour audio-taped individual interview _____ or focus group interview _____ (please choose one form of interview that you feel more comfortable or more articulate).

   Yes _____, and here is my email address _____. No _____.

2. I give informed consent to participate in a survey administered via the clickers.

   Yes _____, No _____.

Besides the two types of data mentioned above, the researcher will conduct classroom observations and gather students' responses to clicker questions related to knowledge building. The classroom observations are conducted to observe group trends; individuals will not be identified in any way. You will always be informed when the observational data is to be collected during lecture.

Are there Risks or Benefits if I Participate?

Benefits – From the perspective of students, participants are exposed to new learning experiences, which are learning with the use of clickers in an active learning environment, and participating in knowledge building (i.e., collaborative creation and continual improvement of new knowledge). From the perspective of future teachers, participants have a hands-on experience of the new style of teaching and learning, which are anticipated to be created for their future students. Participation in the research is a form of reflective practice and critical pedagogy; for example, it is a form of professional learning and professional improvement to question innovations, to analyze the impact, benefits and challenges associated with an innovation and to be involved in the evaluation of a new technology. So, the research is a form of extended professional learning for the participants.

Risks – The risks associated with this research are similar to those encountered in everyday life.

What Happens to the Information I Provide?

Your participation is completely voluntary. Research participation, non-participation or withdrawal will have no effect on student grades, and the course instructor will not know of any specific individual's participation, even after course grades are posted. The course instructor may agree to be identified in the reporting of data; there is a small chance that this may impact the confidentiality of student participants.

You will always be informed when data is being collected for the study – you have the opportunity to decline participation, to withdraw fully from participation after consenting, and to choose not to participate in any particular data collection event by choosing not to enter data using the clicker. You are free to discontinue your participation at any time during the study. If participants choose to withdraw from the research after consenting, the collected data, upon the point of withdrawal, will be retained and used in data analysis and reporting. If the professor chooses to withdraw from the study, all scheduled focus groups will proceed as scheduled, all data collected from you and the professor during lectures, up to the point of withdrawal, will be used in the analysis.

Care will be taken to protect the confidentiality of student participants in a focus group. In a focus group, participants may know each other; thus, anonymity cannot be guaranteed. However, the researcher will request that participants in the focus groups keep comments confidential and refrain from using names.

To keep the information that you provide confidential, NO identifying information is collected. In all reports and analyses, individual students will not be identified. Instead, every attempt will be made to keep individual contributions confidential by identifying "student teacher" as the sole identifiers for this group of individuals. All survey data and content questions data collected during a lecture will be reported as an aggregate. Findings will be available only within contexts outlined in this proposal.

All the data will be collected, analyzed and reported anonymously. Only the researcher and her supervisor can have access to the data. All electronic data will be stored on the researcher's personal computer. All paper data will be stored in the researcher's locked cabinet. All data will be held until 2017 and will be subsequently destroyed. Paper data will be shredded. Electronic data will be deleted and the hard drive erased.

Signatures (written consent)

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate as a research subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature _____Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Angyue Liu
Faculty of Education
403.970.7891
angliu@ucalgary.ca

or

Dr. Michele Jacobsen
Faculty of Education
403.220.4123
dmjacobs@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact the Senior Ethics Resource Officer, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

APPENDIX C INSTRUCTOR CONSENT FORM

Name of Researcher, Faculty, Department, Telephone & Email:

Angyue Liu, Faculty of Education, 403-970-7891, angliu@ucalgary.ca

Supervisor:

Dr. Michele Jacobsen, Faculty of Education

Title of Project:

Exploring the Use of Clickers to Support Active Learning and Knowledge Building by Pre-Service Teachers in Large Lectures

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

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The goals of the research are to explore:

- The ways and extent of using clickers to engage and support pre-service teachers in active learning.
- The possible ways and extent of using clickers to engage and support pre-service teachers in knowledge building (i.e., collaborative creation and continual improvement of new knowledge).
- The benefits and challenges that students and the instructor have throughout the course with the use of clickers.

What Will I Be Asked To Do?

You are being invited to participate in a one-hour audio-taped interview that will occur on campus after the course ends. You are being asked to allow the researcher to conduct observations in your lectures. Care will be taken by the researcher to protect your confidentiality. Your participation is complete voluntary. You have the right to withdraw from the research at any time after consenting. Participation, non-participation or withdrawal will have no effect on your employment with the University of Calgary. Supervisors will not be informed about participation, non-participation or withdrawal.

Dissemination of Findings:

The main use of collected data will be to inform a Masters Degree project that will result in a thesis. The final report may be published online or in print journals and may be presented at local, provincial, national or international academic conferences for the purposes of furthering an understanding of the use of clickers in large-lecture learning environments in higher education.

What Type of Personal Information Will Be Collected?

No personal identifying information will be collected in this study. Unless you give me your permission to cite your involvement as the instructor, your name will not be mentioned in the research. You will only be identified as "course instructor". Besides the interview data, the researcher will gather the knowledge building questions you ask and the teaching strategies you use to support active learning and knowledge building during lecture time.

Data collected from you will include: An **audio-taped interview** and **classroom observations.**

Classroom observation: I give informed consent for researcher to use data that students provide anonymously during the informal, content related questions I pose via the SMART Response XE response system during lecture, and for observations of instructor-student interactions.

Yes: _____ No: _____

- I give informed consent to participate in an **interview.** As part of my consent, I have you my email address to contact me about scheduling participation **in an interview** at a location of my choosing .

Yes: _____, and here is my email address: No Thanks: _____

- As the course instructor, you are publicly associated with this course, so maintaining confidentiality or anonymity will be difficult. Therefore, as the course instructor, do you agreed to be public and cited in the research?

Yes, I agree to be public and cited in the research: _____No Thanks: _____

Are there Risks or Benefits if I Participate?

Benefits - To assist in highlighting specific ways and examples to describe post-secondary, large lecture learning environments that utilize clickers. Faculty and university administrators, instructors and undergraduate students will benefit from context-specific data about successes, impacts of clicker use. The documentation of factors that influence student engagement, participation and learning in large classrooms, can provide insights for instructors to use the best instructional strategies to advance student learning.

Risks – The risks associated with this research are similar to those encountered in everyday life.

What Happens to the Information I Provide?

Your participation is completely voluntary. You have the opportunity to decline participation, to withdraw fully from participation after consenting, and to choose not to participate. You are free to discontinue your participation at any time during the study. If you chose to withdraw from the study, data collected from you and from students during lecture, up to the point of withdrawal, will be used in the analysis; all scheduled interviews with students will proceed as scheduled.

All the data will be collected, analyzed and reported anonymously. The researcher and her supervisor

can have access to the data. All electronic data will be stored on the researcher's personal computer. All paper data will be stored in the researcher's locked cabinet. All data will be held until 2017 and will be subsequently destroyed. Paper data will be shredded. Electronic data will be deleted and the hard drive erased.

Signatures (written consent)

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate as a research subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature _____Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Angyue Liu Faculty of Education 403.970.7891 angliu@ucalgary.ca	or	Dr. Michele Jacobsen Faculty of Education 403.220.4123 dmjacobs@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact the Senior Ethics Resource Officer, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

APPENDIX D STUDENT INTERVIEW PROTOCOL

1) What are the overall benefits of using clickers in the lecture?
2) Do you feel that the use of clickers provided you the opportunities to engage in **active learning** (e.g., active interaction with course content; active reflection on learning materials; active pursuit of learning goals, or anything else)? If yes, please give an example.
3) Do you feel that the open-response (text-entry) clicker questions provided you the opportunities to engage in **knowledge building** (i.e., individual or collaborative knowledge creation, sharing, and improvement)? If yes, please give an example.
4) Do you feel that the class-wide discussion associated with clicker questions influenced your learning (e.g., enhancement or change of your perspective, or anything else)? If yes, in what way?
5) Do you feel that you and other students' contribution in the lecture (i.e., response to clicker questions; participation in discussions) produced **value** to your own and the whole class's learning. If yes, in what way?
6) If you were the instructor, how would you use the clickers in an innovative way?
7) What improvements can be made to the clicker technology or use in lecture that would better support learning and teaching?
8) Students have many reasons for choosing to attend or not to attend lecture. In your opinion, what are some of the factors that impact a student's decision to attend lecture?

APPENDIX E INSTRUCTOR INTERVIEW PROTOCOL

1) In your opinion, what are some of the benefits to you and to your students from using clickers in lectures?
2) What are some of the challenges associated with using clickers in lectures?
3) Do you feel that the use of clickers provided students the opportunities to engage in active learning? If yes, how?
4) Do you feel that the open-response clicker questions provided students the opportunities to engage in knowledge building (i.e. individual and collaborative knowledge creation, sharing and improvement)? If yes, how?
5) In your opinion, how did students' contribution in lectures (i.e., responding to clicker questions; participating in discussion associated with clicker questions) produce value to individual and to the whole class's learning?
6) What suggestions do you have to other instructors who might use clickers to engage pre-service teachers in active learning and knowledge building?
7) What improvements can be made to the clicker technology or use in lecture that would better support learning and teaching?
8) Would you like to teach other education courses with the use of clickers?
9) Students have many reasons for choosing to attend or not to attend lecture. In your opinion, what are some of the factors that impact a student's decision to attend lecture?

APPENDIX F STUDENT SURVEY PROTOCOL

1) I felt comfortable using clickers in large lecture.
2) I felt that the instructor effectively integrated the clickers with the curriculum.
3) My attendance in lectures was increased because of the clicker use.
4) My participation/contribution in lectures was increased because of the clicker use.
5) My interaction with peer students was enhanced because of clicker use.
6) My interaction with the instructor was enhanced because of clicker use.
7) I was more motivated to learn in the lecture because of the clicker use.
8) I was more motivated to learn outside of lecture time (e.g. do more readings and more reflections related to the course content) because of the clicker use.
9) The clicker use helped me improve my understanding of lifelong learning and professional development throughout the course.
10) The clicker use provided me opportunities to immediately apply the ideas/knowledge learned in the lecture.
11) The clicker use provided me opportunities to have a deeper reflection on the ideas/knowledge learned in the lecture.
12) The clicker questions and associated discussion supported a creation of ideas/knowledge.
13) The clicker questions and associated discussion supported a sharing of created ideas/knowledge.
14) The clicker questions and associated discussion supported an improvement of created ideas/knowledge.
15) I felt that the open-ended (text-entry) clicker questions provided more opportunities to create, share and improve idea/knowledge than close-ended (multiple-choice) ones.

16) I appreciated and valued the diverse ideas raised by peers in response to clicker questions and the associated discussion.
17) I learned to work with diversity, and out of that to achieve new syntheses/knowledge, by using the clickers.
18) I felt that my contribution in the lecture (i.e. response to clicker question, participation in discussion) added value to the whole class's learning.
19) The clicker use helped to establish and to develop a community where we learned in a collaborative way.
20) The clicker questions created an authentic learning environment for me (i.e., related learning to real life experience).
21) The clicker use encouraged me to share individual beliefs publicly because of the anonymity that the clicker provided.
22) I was involved in critical thinking/problem solving when using clickers.
23) I was involved in constructive use of authoritative information (i.e. questioning and challenging the authoritative information) when using clickers.
24) The clicker use provided me opportunities to self-assess my learning.
25) The clicker use provided me opportunities to develop stronger epistemological awareness (i.e., what and how I come to know, and also what I do not know and need to learn).
26) I would like to enrol in another education course that uses clickers as part of the learning activities.
27) My interest in implementing technology in my future classroom was increased because of the clicker use.

APPENDIX G STUDENT RECRUITMENT SLIDE

Research: Participant Invitation

- ***Participation is voluntary***, anonymous, and confidential
- No connection w/course grade (i.e., instructor not informed who)
- ***Purpose:*** Study the use of clickers to support active learning and knowledge building in large lectures
- ***Invited to: ① Participate in interview ② Complete a survey***
- ***SIGN Consent form*** and include your EMAIL address

Benefits:

- 1. Hands-on experience & reflection on clicker use helps in thinking of ways to use clickers with your own students
- 2. Your contribution to the research helps us to improve clicker use with other students

APPENDIX H INTERVIEW RECRUITMENT SCRIPT (E-MAIL)

Hello Student Teachers,

Thank you for using clickers as part of your learning experience in the Wednesday evening plenary with Dr. ××. I also thank you for giving your consent for me to contact you about participating in an interview to share your experiences learning with the use of clickers in the plenary, and to help with my masters research study.

I am hoping to schedule you for an interview in March.
I have prepared the following interview schedule, and encourage you to pick a time that works best with your schedule:

Monday, Mar.12, 10:45-11:45;
11:45-12:45;
16:00-17:00
Tuesday, Mar.13, 9:30-10:30;
13:45-14:45
Wednesday, Mar.14, 16:00-17:00;
11:45-12:45
Thursday, Mar.15, 8:20-9:20;
13:00-14:00;
14:00-15:00

Location: Education Tower (EDT), 602W

Please reply to this email, indicating which session you would like to attend. If the times listed above do not work in your schedule, please do let me know and we can discuss other possible times that work better for you.

I appreciate your interest and help.

Sincerely,

Angyue Liu
Masters Student
Educational Technology

Supervisor: Dr. Michele Jacobsen, dmjacobs@ucalgary.ca