Creating active mathematics learning opportunities for students in China:

An action research project in one Chinese high school

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in

The Faculty of Graduate and Postdoctoral Studies

(Mathematics Education)

THE UNIVERSITY OF BRITISH COLUMBIA
(Vancouver)

July 2015

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Abstract

In order to keep pace with the world, China has introduced eight different National Curriculum Reforms (NCR) in basic education since 1949. In the eighth NCR, long-term success of students became the most important and fundamental objective of the reform. More importantly, with respect to mathematics learning, the most recent reform refers not only the acquisition of knowledge, but also refers to the experience of problem solving, communication, and cooperation. Amongst the various factors that may have an impact on mathematics teaching and learning, active learning stands out as having the potential to fulfill students’ long-term development. In the eighth NCR, active learning means learning through doing, learning through experiencing, learning through practicing, and engagement (Li, 2008). However, transitioning from policy design to policy implementation is not easy. In mathematics education, teachers still have to face many challenges in improving their own teaching and advancing their own professional learning.

Considering the context of China, the aim of this research is therefore to explore how high school mathematics teachers in China create active learning opportunities for their students with participation in an action research project. This action research study was conducted at Renhe High School and involved 3 volunteer Grade 10 mathematics teachers and their students (128 students in total).

This thesis reports the strategies that teachers have tried during the study. According to three participating teachers’ experiences, the main strategies that teachers have tried include: introducing activity into class; small group cooperative learning; peer teaching; problem-based
learning; and technology-enhanced learning.

Consequently, by participating in the research, teachers’ experiences revealed various understandings of their own pedagogy, which were influenced or changed during the research. Further, the results of the study show that: (1) Introducing action research approaches could help teachers better understand and utilize “The Standards” to create active learning opportunities for students; (2) Collaboration among teachers enable teachers to examine their classroom instructions, revise current practices and develop new strategies; (3) A supportive school culture can help to overcome the pressure from NCEE (National College Entrance Examination), which often represents an overwhelming influence of classroom practice.
Preface

This thesis is original, unpublished, independent work by the author, L. Yu. The fieldwork reported in this thesis obtained the approval of the UBC Research Ethics Board (Behavioral Research Ethics Board; UBC BREB Number: H13-03419).
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Acknowledgement

My utmost gratitude to my supervisor Dr. Susan Gerofsky, and my other committee members Dr. Cynthia Nicol and external examiner Dr. Anthony Clarke for their support and encouragement. Their valuable insights on mathematics education reform have influenced the shaping of this research study. Their great patience and professional knowledge support me throughout the research and thesis writing process.

I would also like to express my gratitude to the principal, school administrators, teachers, and students in Renhe High School. This study could not be accomplished without their collaboration.

In addition, I would like to express my gratitude to the faculty in the Department of Curriculum and Pedagogy (EDCP) in UBC. I am grateful for the many courses that I have had the opportunity to take in EDCP to learn from various professors and thus grow as a researcher.

Special thanks go to my husband and parents for supporting and encouraging me to pursue my interest further in the field of education.
Dedication

To my parents, husband and baby Ryan
1 Introduction

This chapter serves as an introduction to the study and includes a thesis description, the research questions, an overview of the methodology, and a description of the context of the study.

1.1 Introduction to the study

Since 1949, China has experienced eight different National Curriculum Reforms (NCRs). These reforms, targeting basic education at the pre-primary, primary and secondary levels, attempted to modernize China and position students to adapt to globalization.

In 2001, the eighth NCR revised the curriculum in order to incorporate human characteristics such as creativity, innovation, and entrepreneurship into the classroom. These qualities have since become a focus of education, reinforcing the belief that the quality of China’s workforce is pivotal to the country’s successful economic development (Gao, 2013).

In addition to humanizing education, the eighth and latest NCR also highlighted the need to create active learning opportunities for each student to achieve long-term success (Gao, 2013; Wang, 2011; Wu, 2010; Yang, Ding, & Tian, 2004). According to the eighth NCR (MOE, 2001), active learning is:

\[ \text{… a process, which enables students to become actively involved in learning instead of passively “receiving” knowledge. The process includes reading, writing, discussion, analysis, synthesizing, problem solving and evaluation. Active learning affords students the opportunity to acquire a deeper understanding of course content and material. Active learning is a kind of teaching mode that helps students achieve comprehensive understandings toward knowledge through “doing”. (p. 37) } \]
Moreover, the active learning opportunities are expected to “equip each student with advanced self-learning abilities, problem-solving skills, interdisciplinary understanding, cooperation, innovative consciousness, critical insights, creativity, and responsibility in leading and balancing the society” (Zhong & Tu, 2013, p.18). To accomplish this, the reform emphasizes the value of active learning approaches over traditional knowledge acquisition methods.

However, it is challenging to transition from policy design to policy implementation. Although the documents of the eighth NCR (2001 version) placed active learning as the core part, they fail to help most mathematics teachers to transform from traditional teaching into active learning modes in their classrooms (Wu, 2010). For mathematics education, traditional teaching methods (such as lectures followed by extensive training drill and practice) are still the dominant models in China despite the NCR’s clear mandate for more active approaches to learning (Wu, 2010). Scholars attribute this dilemma to following reasons:

- The documents of the eighth NCR are all about the requirements, the standards, and the principles of active learning. However, they fail to answer questions such as “Why is active learning important for students long-term development?”, and “What strategies could potentially promote active learning?” (Wu, 2010). Such dilemma directly leads to the situation that basic education teachers lack a holistic understanding of active learning. Therefore, the potential and effectiveness of active learning is generally poorly understood and rarely taken up by teachers (Yang & Yu, 2008).
- According to the results of recent studies, traditional teaching methods largely helped
Chinese secondary students obtain high international ranking on mathematics (Zhang, 2005). Based on the results of Yang’s and Yu’s (2008) research, the high international ranking sometimes makes it easier for teachers dismiss the drawbacks of traditional teaching modes, such as it is weak on helping students solve complex and open-process mathematics problems, which are essential for students’ creativity, critical thinking and personal long-term development.

- According to the reviews of research about the eighth NCR, teachers have to face considerable challenges in attempting to create active learning opportunities for their students in the classroom. These challenges, which prevent teachers from transforming traditional teaching practices into active learning approaches, include: (1) lack of required teaching guides for understanding the interaction between the standards and active learning; (2) difficulties in finding potential strategies to promote active learning; and (3) the still overwhelming pressure from the National Collage Entrance Examination (NCEE) that places emphasis on end-of-year exam score above all other elements of a school curriculum (Gong, 2008; Huang & Long, 2008; Luo, 2008; Lv & Guo, 2008; Lv, 2013; Yang & Yu, 2008; Xu, 2010; Zhang, 2008).

Therefore, under such circumstances, to attempt to better understand how Chinese teachers strive to create active learning opportunities for their students becomes an important question in the eighth NCR context (Lv, 2013).
1.2 Research questions

Considering the current educational context in China, this study investigates how teachers help students develop active relationships with mathematics and ultimately promote active learning opportunities for them in the mathematics classroom. This study is framed by the overarching research question:

**How do high school mathematics teachers in China create active learning opportunities for their students?**

The exploration of this question is assisted by three sub-questions:

**With respect to creating active learning opportunities within the mathematics classroom:**

1. What approaches have teachers tried and what challenges and successes do teachers report prior to the study?

2. What strategies do teachers try while participating in an action research group?

3. How are teachers’ understanding of their practice changed with their participation in the action research group?

1.3 Context

1.3.1 China’s National Curriculum Reforms

Since the early 1950s, China’s basic education system, including pre-primary, primary and secondary education, has been modified eight times by National Curriculum Reforms (NCR) overseen by the Ministry of Education’s (MOE). These reforms were designed to serve different
goals at different times, including political, economic, scientific and technological developments (Li & Xu, 2004; Wang, 2013). During each National Curriculum Reform, the MOE was “responsible for making overall curriculum plans, formulating curriculum management policy, establishing what curricula are to be included and how many teaching and learning hours are to be dedicated to them collectively and individually in the national curriculum” (Zeng & Zhou, 2013, p. 271).

In China, each NCR functions as a “top-down, policy-driven, and nation wide curriculum reform” (Zeng & Zhou, 2013, p. 273). In order to secure successful implementation of each NCR and their individual requirements, national, provincial, and school level curriculum management systems included in the process (Zeng & Zhou, 2013). The following table (table 1.1) is the timeline of China’s eight NCRs (Wang, 2011, my translation).

**Table 1.1: Timeline of China’s eight NCRs**

<table>
<thead>
<tr>
<th>Time</th>
<th>Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first NCR (1949-1954)</td>
<td>The first curriculum reform in China took place in the early 1950s after the foundation of the People’s Republic of China (PRC). The aim was to establish a framework for basic education (including pre-primary, primary and secondary education) curriculum system by learning from the Soviet Union’s experiences while also including useful experiences from China’s past.</td>
</tr>
<tr>
<td>The second NCR (1954-1957)</td>
<td>The purpose of the second NCR was to further develop the basic education system established by the first NCR, revise teaching schedules, the national syllabus and textbooks in use.</td>
</tr>
<tr>
<td>The third NCR (1957-1963)</td>
<td>This reform was carried out in order to strengthen the centralization of the basic education system by copying the Soviet Union’s experiences. During this period, a comprehensive basic education system was established, but national public acceptance and implementation was difficult.</td>
</tr>
<tr>
<td>Time</td>
<td>Objects</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>The fourth NCR (1963 - 1978)</td>
<td>In order to include the most recent achievements in sciences and technology, the fourth version of the national basic education textbooks was published in 1963. However, implementation of the reform ceased after the “Cultural Revolution” began in 1966. The “Cultural Revolution” was a social-political movement that took place in China from 1966 until 1976. During these ten years, China saw a nationwide suspension of primary and secondary school classes. Due to the suspension, the fourth National Curriculum Reform only lasted for three years from 1963-1966.</td>
</tr>
<tr>
<td>The fifth NCR (1978 - 1980)</td>
<td>The fifth NCR was developed and implemented upon the termination of the Cultural Revolution. During this reform, the new national basic education syllabus was promulgated and the fifth edition of national textbooks was introduced.</td>
</tr>
<tr>
<td>The sixth NCR (1980 - 1986)</td>
<td>In order to encourage implementation of innovative teaching modes in basic education classrooms, the sixth edition of the national basic education textbooks and other educational materials were introduced. Moreover, for the first time extracurricular activity was introduced in the sixth NCR.</td>
</tr>
<tr>
<td>The seventh NCR (1986 - 1996)</td>
<td>Between 1986 and 1996, the seventh reform was carried out in an effort to promote school vitality, improve the educational system, spread the compulsory education further and ameliorate the rigid education system. In addition, students’ all round development was stressed in the seventh NCR.</td>
</tr>
<tr>
<td>The eighth NCR (1996 - present)</td>
<td>In 1996, a pilot draft of the eighth National Curriculum Reform (also known as the New National Curriculum Reform) outline was promulgated. The Ministry of Education disseminated an outline of the Basic Education Curriculum Reform (implementation) (2001) and it was implemented nation-wide by 2003. “The eighth curriculum reform laid out the blueprint of China’s basic education curriculum reform in the new century with a new discourse system, reflecting the progressive tendency of curriculum theory and curriculum reform practice of the time” (Zhong, 2006, p. 373).</td>
</tr>
</tbody>
</table>

### 1.3.2 The eighth National Curriculum Reform

After 2000, economic globalization increased the spread of curriculum reforms across nations (Astiz, Wiseman, & Baker, 2002; Baker, 1999; Liu, 2013). In a political response to this global connectivity, many countries expanded their education goals to adapt to the international changes and position their countries as global competitors (Astiz et al., 2002; Liu, 2013). In 2001, the eighth NCR, generally referred as the “New Curriculum Reform,” evolved from this need in
an attempt to modernize China and position the country amidst the changing global economy (Zeng & Zhou, 2013).

The aim of the eighth NCR was to establish a system that would empower teachers and students (Zeng & Zhou, 2013). Importantly, the eighth NCR was intended to transform the curriculum system from a traditional “discipline-centered, classroom-centered, teacher-centered” approach to a “real-life related, learning-centered, student-oriented” active learning system (MOE; Zhong & Tu, 2013, p.18).

In response to these changes, increasing needs for a new education system to promote active learning in classroom were stressed in the implementation of the 2001 “New Curriculum Reform” in basic education. The newly developed Western academic thinking, theories and standards related to active learning were also introduced in the New Curriculum Reform to help teachers create active learning opportunities for their students (Chen, 2013; Liu, 2013). In the document for the design and implementation of the New Curriculum Reform, MOE stipulates the following (MOE, 2001; Sargent, 2009):

Change the overemphasis on transmission learning in the implementation of curriculum, and the emphasis on rote memorization, and mechanical drill. Promote instead students' active participation, their desire to investigate, and eagerness to use their hands. Develop students' ability to collect and process information and to analyze and solve problems. Cultivate also the capacities for cooperation and communication. (p. 3)

Apparentl, the new curriculum policy change has been systematically designed with rationales that intend to break from the traditional teaching approach, and to seek a more active learning system. In order to better understand the new curriculum policy change, the following
section will compare and discuss the traditional mathematics teaching and active mathematics learning in China.

1.3.3 Traditional mathematics teaching and active mathematics learning in China

According to the results of recent studies, Chinese secondary school students in general outperform the majority of students around the world in mathematics (Aunio, Aubrey, Godfrey, Pan, & Liu, 2008; Gonzales et al., 2004; Peterson, Woessmann, Hanushek, & Lastra-Anadón, 2011; Stevenson & Stigler, 1992). In the book “Learning Gap: Why our schools are failing and what we can learn from Japanese and Chinese education” (Stevenson & Stigler, 1994), Stevenson and Stigler argued that examining mathematical teaching approaches in China provides a framework to understand mathematics classroom teaching in North America. From this quote we can assume that the authors are impressed with the mathematical teaching approaches in China.

However, although the existing Chinese mathematics teaching system successfully leads Chinese secondary students to high international ranking in the subject in the point of graduation, some contend that this teaching system fails to keep Chinese students ranked first in the long-term (Zhang, 2005). According to Wang (2005), Chinese students’ performance is not substantially better than their U.S. and Japanese counterparts one or more years after graduation. Chinese students often failed in solving complex and open-process mathematics problems, which Cai and Silver (1995) claim are essential for students’ creativity, critical thinking and personal long-term development. Therefore, from this perspective, the mathematics teaching in China was
an “important and illustrative failure” (Zhang, 2005, p. 35).

Some scholars attribute these conflicts to traditional teaching approaches, which are dominant models for current instruction in China (Wu, 2010). As discussed above, traditional mathematics teaching in China is “discipline-centered, classroom-centered and teacher-centered” (Zhong & Tu, 2013, p.18) set within the following context (Zhu & Peng, 2000, my translation):

1. Most classrooms contain over 40 students. Due to a lack of educational resources, classrooms in rural schools can reach up to 90 students. Students sit in pairs or by themselves in the classroom, fostering competitive and individual environments. Competition is encouraged among students in an attempt to see which students are the “best”. Students normally work individually without paying attention to or interacting with other students. Students in mathematics classes seldom study cooperatively and this discourages students from developing interest in other students’ learning in addition to their own.

2. Due to fixed lesson plans, teachers employ the same teaching approaches students for years. The design of the math class outline is based on the discipline, not the students’ real situation. A typical math class normally contain four parts: (1) review and introduction, (2) lecturing, (3) practice and extension, (4) summary and homework. Teachers stand in front of the classroom and spend most of the class time (typically 40 to 45 minutes), lecturing or with students working silently. Students are taught facts and processes that seldom relate to the real world. Teaching is mainly focused on finding the right answers to problems. The “review and introduction” and “summary and homework” parts, normally take no more than 15 minutes in total.

3. Teachers are always the leaders of the class. Most of the class time is spent with the teachers explaining or lecturing while the students watch and listen. The instruction mode is teacher-dominated. The class is taught as a whole, with little opportunity for students to interact with teachers or collaborate with other students. All of the students are expected to cover the same amount of material, in the same way and at more or less the same pace.

4. The role of the student is to listen carefully to the teacher and to understand the mathematics knowledge by doing lots of exercises. Students prefer to work alone in silence. The role of the learner is also to memorize the facts and rules that are learned in class and to implement them.

5. Students are tested weekly and are ranked according to their test scores. Teachers adjust the amount of homework, proportion of in class practice and difficulty of problems according to the test results. (p. 86)
In addition, the traditional teaching modes mainly focus on competition, management and group aptitude. Success is based on speed, where the idea that students who are good at math are those who solve problems the quickest (Boaler, 2013; Schoenfeld, 1988; Zhang, 2004). Furthermore, teachers evaluate individual student success by students’ ability to give the right answers to the questions and tests provided by the teacher, as many as possible, as fast as they can (Skemp, 1986; Zhang, 2005). Schoenfeld (1988), among others, suggest that these impede students’ acquisition and use of other mathematical knowledge.

More importantly, due to the lack of interaction between teachers and students in traditional teaching classes, students do not experience active learning and instead sit passively through lectures (Zhu & Peng, 2000). Memorization, repeated practice and sheer hard work (that is, more repetition and memorization) are still emphasized as the primary way for Chinese students to understand classroom material (Zhang, 2004). This has resulted in the widespread dissemination of passive learning, which directly influences students’ psychological and long-term personal development (Zhang, 2005). Subsequently, students’ interest, autonomy, creativity and practical skills are overshadowed and diminished by traditional mathematics teaching.

As an interesting footnote, studies based on the results of a 2012 nationwide survey comparing students from 20 central Chinese cities, 40.91% of high school students were found to have psychological problems (Yu, 2012). Of these students, 7.68% suffer from suicidal tendencies (Yu, 2012). Among the factors that contribute to the psychological problems of
Chinese students, school issues are the largest (Liang, 2000). This problem is especially present in high school math classrooms (Yu, 2012). Although cause and effect cannot be directly attributed to anyone factor, these results do call into question the current educational practices in schools, including the traditional teaching methods.

Apparently, although active learning has been stressed in the eighth NCR, this emphasis has been promoted for the past for at least 10 years but its actual implementation has proven more difficult (Astiz et al., 2002). From 2001, the curriculum reforms have not been able to transform traditional teaching modes into active learning approaches. Importantly, the greatest resistance is widely seen in high-school classrooms (Yu, 2012).

Due to these findings, more emphasis on active learning is being placed in the second stage of new curriculum reform (from 2010 to 2020) in order to promote students’ long-term development and an active relationship with mathematics. Active relationships promote cooperation among students and enhance active engagement with mathematics by emphasizing student participation in the learning process (Kyriacou, 1992). In this respect, the MOE promulgated “New National Mathematics Curriculum Standards” in 2011, which have promoted instructional practices for teachers to teach in order to help students learn in active ways. For example, “The Standards” (2011 revision) defined the following key objectives as guidelines for classroom teaching (Ministry of Education, 2011, my translation):

- Changing the teaching and learning focus from “basic knowledge and skills” to the “capacity of students to engage in critical thinking, problem solving and creativity”;
- Changing teacher-centered teaching modes to more student-centered modes, with more
emphasis on student engagement, coordination and communication;

- Teaching mathematics as a tool in people’s daily life, work and study, and a part of human culture;
- Learning materials of mathematics should be practical, significant and challenging, and mathematics teaching methods should be pragmatic, innovative and encourage self-exploration;
- A teacher is an organizer, supporter, and cooperator in mathematics study while the students should take the lead;
- Pay considerable attention to both the process and outcomes in mathematics learning. (p. 214)

According to these changes, active learning in mathematics has captured increasing attention from researchers, teachers and policy makers in China in recent years. A sequence of local level public discussions followed the introduction of these educational changes. For example, these discussions explored how to create active learning opportunities for Chinese students within the context of mathematics classroom (Lv, 2013; Wu, 2010 and my experience).

1.3.4 Professional development and challenges of creating active learning opportunities for students in China

Along with the development of the second stage New Curriculum Reform (2010-2020), political leaders and the MOE continue to face challenges in promoting active learning within Chinese classrooms (Lv, 2013). Many scholars believe success of the New Curriculum Reform hinges on the quality of its teachers, which is a core issue for the development of China’s education (Wu, 2010). Therefore, the necessity of promoting teachers’ own professional development has become the main theme of basic education. Preparing high-quality teachers to fulfill the new curriculum reform objectives has gradually become a new focus in Chinese
Moreover, the emphasis on teachers’ professional development has led to policy shifts. In 2011, the “Long-term Education Reform and Development Plan in China” advised local administrative departments to develop effective, ongoing professional development programs to encourage and support the professional development of teachers (MOE, 2011). These policies lead to the establishment of various in-service teacher education institutions, many of which offer a variety of professional development programs for teachers.

The growth and availability of these development programs have provided more and more teachers with the opportunity to enhance their teaching methods and cultivate their understanding of active learning. However, as mentioned previously, transitioning from policy design to policy implementation is not easy. In mathematics education, teachers still face many challenges in improving their teaching and engaging in professional learning that has a focus on creating active learning opportunities for students, in the context of their own classroom (Lv, 2013).

As mentioned before, “The Full-time High School Education Mathematics Curriculum Standards” (“The Standards”) are considered as suitable teaching guidelines for teachers to promote active mathematics learning. However, the education reform process does not necessarily follow the guidelines of “The Standards”. After “The Standards” were promulgated in 2001, studies on the implementation of the new mathematics curriculum were initially focused on the implementation status of “The Standards” for the subsequent 10 years (Lv, 2013). According to the results and reviews of the “understanding and application of ‘The Standards’ by teachers”, most of
today’s teachers understand “The Standards”, but “teachers that ‘completely understood’ and ‘often’ utilized ‘The Standards’ were few” (Lv & Guo, 2008; Lv, 2013; Gong, 2008; Yang & Yu, 2008; Huang & Long, 2008; Luo, 2008; Zhang, 2008; Xu, 2010). Therefore, teachers require more guidance in order to utilize “The Standards” (Wu, 2010).

Teachers are offered with four channels to understand “The Standards” and assist them to develop professionally in this regard (Wu, 2010):

1. basic education teacher journals;
2. in-service teacher professional upgrading programs;
3. textbooks and other learning materials;
4. popular media.

In-service teacher professional upgrading programs are by far the most direct and, in some ways, the most ideal channels to provide teachers with opportunities for professional development (Amit & Fried, 2008). These programs would ultimately help teachers to develop active learning in their relationships with students in the mathematics classroom.

However, research has revealed that in-service teacher professional upgrading programs in China has been insufficient in providing guidance to implement these curriculum reforms (Liu, 2013). Most theories and guidelines offered in the programs are outdated or borrowed from Western countries with little adaption to the Chinese context (Liu, 2013; My experience). Moreover, some programs are not supported or recognized by teachers and unfortunately, many teachers view the programs as waste of time (Liu, 2013; My own experience). Due to this stigma,
many teachers regard the assistance they receive in understanding “The Standards” as superficial and perfunctory (Lv, 2013). Consequently, this lack of guidance, and ultimately, understanding of “The Standards” and related mandates poses the main challenge for teachers to overcome barriers for creating active learning opportunities for their students.

Aside from in-service teacher professional upgrading programs, basic education teacher journals are an important means to improve and support teaching. Unfortunately, studies in journals on promoting active learning in reform-oriented classrooms are rare on basic education teacher journals (Xing, 2005; Xue, 2007). More importantly academic journals also fail to offer solid data regarding which strategies have the potential to promote active learning (Wu, 2010). Therefore teachers do not have easy access to the information they require, which further hinders the creation of active learning opportunities for the students in their classrooms.

In many countries, tests are traditionally used to measure student proficiency. In China, tests measure success and achievement and are used extensively for selection and accreditation processes (Huang & Lee, 2013). As a result, test results often dictate classroom teaching methods and influence student learning (Huang & Lee, 2013; Qi, 2005). For these reasons, testing can be viewed as a powerful tool that can change and affect teaching and learning in classrooms (Lv, 2013). Unless testing processes in China are critically reviewed and practices altered, there is unlikely to be substantial changes to educational practices in Chinese classrooms. In particular, the national college entrance exams is one of the most overwhelming influence on what happens in classrooms throughout China, reminiscent of the older but relatively recently abolished Empirical
Examination System (removed in 1905) used for entrance to the Public Service in China.

With the National Collage Entrance Examination (NCEE) system, China has the longest examination history in the world (Huang & Lee, 2013). This powerful tradition, combined with the intense pressure for students to succeed on the NCEE, encourages high school mathematics teachers to emphasize the need for higher end-of-year test scores at the expense of the students’ overall personal long-term development (Huang & Lee, 2013). Since examination results determine students’ entrance options in higher education, teaching expectations are also influenced. Moreover, access to careers across a range of areas, from science to economics, are determined by successful performances in mathematics, which are measured by the NCEE standardized exams. Pressure to succeed on these examinations is exacerbated by students, parents, schools and society who readily conform to and comply with this system of evaluating student performance. To ensure student success on the NCEE, teachers use NCEE-oriented practices (e.g., endless drill and practice) even though they realize it prevents students’ long-term development (Lv, 2013).

1.4 The study

Considering the current situation (i.e., the eighth NCR) and challenges mentioned above (e.g., the national college entrance exams), the aim of this research is therefore to explore how high school mathematics teachers in China creating active learning opportunities for their students with support of action research approach. Since action research could effectively provide opportunities for school-based curriculum development, professional growth, and school improvement (Popplewell & Hayman, 2012), this study draws on action research to better understand and
explore the ways in which teachers are responsible to the eighth NCR imperative for active learning. Further methodological description and justification for using action research in this study is provided in Chapter 3. Within the context of teachers’ own classrooms, this action research study was intended to help teachers improve their practices, collaboratively overcome those challenges, and eventually create active learning opportunities for their students. This study was conducted at Renhe High School (all the names in this study are pseudonyms) and involved 3 volunteer Grade 10 mathematics teachers and their students (128 students in total). Eileen Ferrance’s (2000) action research cycle (Figure 3.1) was introduced to illustrate the process and steps of this study.

Drawing on an “action research cycle” (Figure 3.1), the study was divided into three phases: “Participating in active learning workshops (1 month)”, “Creating active learning opportunities (2 months)” and “Sharing reflection on experiences (1 week)”. These phases were developed in alignment with 18 pre-arranged research team meetings. Three participant teachers, the principal of Renhe High School and I are research team members. As a team we met once a week for about 1 hour. All meetings were videotaped in order to capture teachers’ initial understanding of active learning. Field notes were written during and after each research team meeting to further clarify the tapes.

A month-long workshop was carried out during the first phase of the study. This research segment was designed to help each teacher understand principles of active learning, the potential strategies to promote active learning, and “The Standards” mentioned in the New Curriculum
Reform. Following the workshops, teachers would employ active learning approaches in their classrooms. Teachers studied their own practice through writing TR (Teaching Reflection), collecting and analyzing students’ work samples, observing students, and informally interviewing students. During this phase, the critical friend (the principal) and I attended the teachers’ classes together to understand how teachers taught a lesson. Specific description of the critical friend (the principal) is provided in chapter 3. Observations began on the first day of research lesson tryout and occurred once a week for each class. I took field notes and took photos during each observation. One-on-one interviews were conducted with each teacher before and after the research lessons. These interviews provided a baseline for me to assess and evaluate changes in each teacher’s understanding of their practice with their participation in the action research group. A final reflection was also conducted in the last phase of the research which the teachers collectively shared their thoughts and experiences.

1.5 Thesis outline

This thesis consists of the following five chapters:

Chapter 1, Introduction, which discusses the Chinese education reform context, as well as the features of all China’s eight times National Curriculum Reforms (NCR). Overarching research questions and guiding questions are presented, and the distinguishing characteristics of traditional mathematics teaching and active mathematics learning in China are mentioned in this chapter. The challenges in professional development and creating active mathematics learning opportunities are highlighted, and the study’s methodology and methods are also described.
Chapter 2, Literature review, which addresses existing literature related to active learning. This chapter defines active learning, reviews its historical development in China and explores its theoretical and practical significance. Professional development in China and existing research on active learning in mathematics are subsequently analyzed. Potential strategies for promoting active mathematics learning in China are assessed and a brief description detailing why these strategies are suitable for China’s current situation is also discussed.

Chapter 3, Methodology and methods employed, which describes the action research approach in detail in order to explain this study’s implementation. The study’s methods, data sources, and data analysis process are outlined. Moreover, the action research cycle is discussed in greater detail.

Chapter 4, Findings, which presents the respondent analysis of three participating teachers (namely Lee, Sue and Hen). The teaching practices they have tried, the challenges and successes they reported before participating in the action research were analyzed first, and followed by the strategies each teacher tried while participating in the action research group. In addition, these teachers’ understandings of their own practice, which had changed with the participation in the action research group were analyzed.

Chapter 5, Conclusions and implications, which present the conclusion accompanied with a discussion exploring the rationale for the measured changes in active learning and teacher professional development. Suggestions for overcoming challenges that emerged during the research are subsequently discussed. Requirements and guidelines for creating active learning
opportunities for students are provided and accompanied by considerations on future implementation of this study.
2 Literature Review

This chapter explores the theoretical and practical significance of active learning. Through the analytical review of existing research, the historical development of active learning in China is examined and potential strategies for promoting active mathematics learning in China are identified. Evidence supporting the application of these strategies in China’s current education system is also presented.

2.1 Active learning in China

Theoretical research and exploration in active learning began early in ancient China. Over 2400 years ago, Chinese philosopher Xun Zi (340-245 BC), who was one of the three greatest Confucian scholars of early China, declared: “Not having heard something is not as good as having heard it; having heard it is not as good as having seen it; having seen it is not as good as knowing it; knowing it is not as good as putting it into practice” (Lu, 2012). These four simple statements from Xun Zi point out the most important characteristics of active learning (Silberman, 1996). Since Xun Zi pointed out the importance of active learning, the development of the concept has undergone three major phases (Lu, 2012).

- The first phase (340 BC - 1905 AD)

Xun Zi is treated as the first educator in Chinese history who formally stated the significant impact of “practice” in his book “Ruxiao” (Li, 2004). He pointed out that learning should not be solely established on the basis of speaking and listening, but should emphasize “practicing” (Li, 2004). In “Ruxiao” Xun Zi described various meaning of “practice” through...
some easy understanding little stories. It means learning through doing, learning through experiencing, learning through practicing, and engagement (Li, 2008). These phases that Xun Zi used to express the meaning of “practice” 2400 years ago are still as the essence of active learning today.

However, during Xun Zi’s time, ancient China was still in the primary stage of feudal society. Influenced by politics, economic poverty and war, people’s education level was generally low (Li, 2005). Therefore, the importance of active learning remained widely unrecognized during that period (Li, 2004). Moreover, constructed from the restrictions of feudalism, Xun Zi believed that teachers should be the center of the teaching and learning process. He thought teachers possessed a unique authority over students and students should obey teachers as much as possible (Li, 2004).

It is worth mentioning that although Xun Zi’s educational ideas significantly influenced people’s attitudes toward active learning, it did not make the same impact as an important feature of Chinese society that arose in the 18th century. Among all the factors that impede active learning development after Xun Zi’s time, the “Imperial Civil Examination System” would be the most influential one (Hu, 2010). In fact, the Imperial Civil Examination System lasted for almost 1300 years in China. Originating in the Sui Dynasty in 607 AD, the system didn’t reach its peak until 1368 AD in the Ming Dynasty and remained prominent until its abolition in the late Qing Dynasty (1905) (Cao, 2003). The Imperial Civil Examination was a highly centralized civil service examination system used for the purpose of selecting the best potential candidates to
serve as administrative officials (Yuan, 1995; Zhang, 2007).

The Imperial Examination System was not established by chance. Instead, it was the result of China’s socio-economic and bureaucratic development (Jiang & Yang, 2006). The Imperial Examination System was an empire-wide selection process operating on the principle that officials must be selected according to ability and intellectual achievement rather than one’s birth (Yuan, 1995). Since it provided lower social class commoners with the opportunity to compete with the privileged for social class mobility, the Imperial Examination System was highly respected by ambitious commoners for over a thousand years (Yuan, 1995; Zhang, 2007).

Although the Imperial Examination System was not actually an educational system in itself, it effectively oriented the country’s education for about thirteen hundred years and left traceable impacts on current Chinese culture and society (Yuan, 1995). Under the Imperial Examination System, educational concepts were limited to Confucian classics that operated within strict requirements. This system programmed China’s education system to become rigid and inflexible, where education’s only purpose was to ensure exacting recitation of the works of ancient scholars through memorization and repetition over a 9-day examination period in which candidates were confined to a small cell-like space sealed and secluded from the outside world (Kang, 2009; Yuan, 1995). Under such circumstances, active learning was limited and ultimately dismissed as a teaching method during this period (Lu, 2012).

● Phase two (1905 - 1948)

With the abolishment of the “Civil Service Examination” in 1905 and the end of feudal
education, China entered into the modern education era (Curran, 2005; Ma, 2001). From the beginning of the 20th century through the 1940s, driven by military aggressions from the Western powers and Japan, and spurred by the impact of Western civilization, China experienced political, economic, cultural and educational upheaval (Ma, 2001). Chinese intellectuals hoped to save China and turn the country into a strong power by establishing new thoughts, modes of life, literature, and most of all, a new education system (Sun, 1999; Zeng, 1988).

Inspired by the successes in Great Britain’s, Germany’s and America’s education systems, modern education in China insisted that Chinese people should open up to the outside world in order to reform the education system (Ma, 2001; Yang & Yang, 2013). In order to turn China into a stronger nation, advocates claimed that learning Western sciences and technology was the most powerful way to defeat Western powers and Japan (Su, 1995; Zeng, 1988). Therefore, beginning in the 1910s, a large number of foreign scholars were invited and Western-style schools founded in China. For example, Western scholars spent considerable time in China during this period and had a significant influence of the development of educational thought in China. Further, foreign languages schools, industrial and technical schools, and military academies were set up in cities like Beijing, Shanghai, and Tianjin (Zeng, 1988). These cities followed the Western theories, which were successfully introduced into a modern educational approach in China (Ma, 2001; Su, 1995; Sun, 1999; Zeng, 1988).

During this period, educational curricula expanded to include natural and social scientific knowledge and mathematics was formally included in basic education for the first time (Zeng,
Moreover, this new school of thought not only brought Western ideas into China, but also encouraged students to study abroad. Consequently, during the 40 years that followed, hundreds of students were sent out annually to study military sciences, machine manufacturing, education, economics and so forth (Ma, 2001; Zeng, 1988). Perspectives of respecting students’ interest and personality were gradually recognized by educators and the public and the desire to reform the Chinese education system grew (Ma, 2001; Su, 1995).

Under these conditions, China began to revitalize active learning concepts. Among the educators who made contributions to the development of active learning during this period, John Dewey was the most influential one (Huang, 2009). Dewey’s educational ideas in relation to active learning and exerted tremendous influences on the Chinese education system from the beginning of the 20th century through to the establishment of the New China in the late 1940s (Ma, 2001; Zeng, 1988).

During this time, Dewey’s former students evolved as China’s major teacher-training institutional leaders (Hu Shi, Tao Xingzhi, Chen Heqin and Cai Yuanpei). They were all highly influenced by Dewey’s educational theories and regarded his work as the blueprint for Chinese education (Zeng, 1988). For this reason, Dewey’s educational ideas were introduced to China prior to his visit to the country in 1919 (Sun, 1995). During his two-year visit from 1919-1921, Dewey’s ideas received widespread attention and saw the zenith of his influence on promoting active learning (Su, 1995; Sun, 1999; Wang, 2008; Zeng, 1988).

Based on the idealistic philosophy of pragmatism, evolutionism, and his children-centered
theories, Dewey was widely treated as one of the most famous proponents of hands-on learning and experiential educators of this time both in his American home and abroad (Zeng, 1988). Dewey advocated on behalf of many key components of active learning including introducing activities into the learning process, learning through experiencing and children-centered learning (Su, 1995). According to Dewey, “If knowledge comes from the impressions made upon us by natural objects, it is impossible to procure knowledge without the use of objects which impress the mind” (Dewey, 1916/2009, p. 217-218). Besides, Dewey had keen insight concerning the position of activities and experiences in the process of education. He emphasized that activities and experiences would be the most influential factors on cultivating children’s independence and creativity in learning (Zeng, 1988).

Unlike Xun Zi, Dewey encouraged teachers to follow the main rules of active learning. According to Dewey’s educational theory, teacher should not use passive learning approaches in their classroom (Rodgers, 2002). In other words, teachers should not lecture endlessly, but instead facilitate learning and guide student discovery. As Dewey (1897) explained in “My Pedagogic Creed”:

The teacher is not in the school to impose certain ideas or to form certain habits in the child, but is there as a member of the community to select the influences which shall affect the child and to assist him in properly responding to these. Thus the teacher becomes a partner in the learning process, guiding students to independently discover meaning within the subject area. This philosophy has become an increasingly popular idea within present-day teacher preparatory programs. (p. 431)

Moreover, Dewey's theories of education put a premium on meaningful activity and participation during the learning process (Garrison, Neubert & Reich, 2012). Unlike traditional
teaching modes, which relied on authoritarianism and rote learning, Dewey asserted that the learning process should be relevant to students’ lives (Rodgers, 2002). He treated learning by doing and practical life skills development as the crucial aspects of students’ development (Hill, Rowan & Ball, 2005; Garrison et al., 2012, & Rodgers, 2002).

From the 1920s to the 1940s, Chinese education was dominated by Dewey’s theories (Su, 1995; Sun, 1999). Many teaching methods in China also went through significant transformation based on Dewey's ideas (Ou, 1970; Su, 1995). Children became the center of the school. Strategies utilizing aspects of self-study and group work were adopted in school systems, further promoting active learning (Zeng, 1988). However, the period from 1920s to 1940s China was a time of political turmoil, civil war and foreign occupation in China and most of the schools were closed during this time. Nonetheless active learning received unprecedented attention during this time (Zeng, 1988).

Overall, the success of active learning remained was linked to Dewey’s influence on educators in China, not to the public realization of its importance (Sun, 1999). Therefore, after the 1940s and due to the political forces as play, Dewey’s influences in China gradually declined and so did the opportunities for building a strong belief in active learning throughout the educational system. The implementation of the methods required a transformation of cultural values also waned (Su, 1995). Although Dewey’s reform strategies were considered important among many educators, it was difficult to adapt them to meet China’s evolving needs and political imperatives of the day (Su, 1995; Zeng, 1988). The reform-based teaching methods
lacked theoretical testing and statistical analysis, which made it impossible to be evaluated and developed (Zeng, 1988). In fact, when China adopted Marxism, Dewey’s theories of education became widely doubted and criticized (Su, 1955; Sun, 1999). His educational theory was “blamed for the lack of discipline, lack of teacher authority, and therefore the lack of rigorous teaching and learning in the schools” (Zeng, 1988, p. 313). Consequently, in the mid 1950s, Dewey’s efforts were lost and forgotten and so too was the principal of active learning that defined his educational philosophy (Sun, 1999).

- Phase three (1949 - Present)

Beginning in 1949, after eight NCRs in China, active learning began to appear in education and increasingly was treated as a core element of teaching and learning process in the eighth NCR (Chen, 2003). As mentioned in chapter one, although active learning faces considerable challenges in the current Chinese context, it continues to see systematic development in many parts of China (Shao, 2009; Yi, 2000). Active learning is no longer regarding as being comprised of purely copying Western countries’ experiences and theories. Instead, active learning has evolved into a combination of China’s unique condition and Western countries’ contributing theories (Shao, 2009). The next section outlines the main aspects that contribute to the development of active learning in China today.

(1) Exploring the phases of active learning

Through the literature review, from the perspective of students, active learning within the context of Chinese cultural foundations of learning can be though of as being developed in three
distinct phases: “unconscious of active learning, conscious of active learning, highly engaging” (Xue, 2007). In the first phase (unconscious of active learning) students do not understand the learning objectives. Instead, they blindly follow the teachers (Xue, 2007). Students are not aware that they are the center of the learning process and instead treat their role as “receiving” knowledge and obeying the teachers. In this phase, the challenge is how to get students effectively and actively engaged would be one of the first thing teachers have to consider. Research suggests that most high school students in China are currently trapped in this phase (Wang, 2005; Xing, 2005).

The second phase, (conscious of active learning) describes how students have the desire and realization to become actively involved in the learning process, but commonly do not reason or argue for it (Xue, 2007). This phase is considered as the key point helping students transfer to the final phase. For teachers, they need to design instruction in more effective ways in order to motivate students towards being open to being actively involved in their own learning.

In the final phase (highly engaging) students are highly engaged and motivated in the learning process and have positive attitudes about active learning (Xue, 2007). Students tend to rely less on teachers and have clear realization that the role of the learner is to construct knowledge, not just receive it (Zhang, 2003). This phase also involves transference, meaning being able to transfer attitudes toward learning to various perspectives toward of life. The second and the third phases are commonly considered to be the key components in students’ long-term development (Xue, 2007; Zhang, 2003).
(2) Exploring factors influencing active learning

Through field research and the literature study, scholars identify students, teachers, and schools as the main factors that influence active learning (Chen, 2003; Shao, 2009; Xue, 2007; Wang, 2007; Zhang, 2003). Students’ attitudes toward active learning could directly determine the effectiveness of active learning approaches in the classroom (Shao, 2009; Xing, 2005). In fact, one of the main challenges to active learning exists within the students themselves. Students tend to prefer to work alone or in small groups with acquaintances and dislike aspects of active learning that encourage group collaboration (Xue, 2007; Zhang, 2003). Furthermore, students are often more comfortable with the teacher ‘telling’ them what they need to know rather than inquiring into and contracting that knowledge themselves (Zhang, 2003).

However, it is teachers who are considered to be the most influential factors in promoting active learning (Shao, 2009; Xue, 2007). Many researchers seek to answer questions of whether teachers recognize the significant impact of active learning, if they are motivated to learn more and if they can determine what strategies would be the most suitable to help their students (Chen, 2013; Lv, 2013; Xue, 2007).

These same scholars believe that schools should take responsibility for educational innovations and school-based curriculum development (Law & Xu, 2013; Shao, 2009). Additionally, “the schools are entitled to develop or choose the suitable curriculum by considering local social and economical situations, traditions and advantages of the schools themselves, and interests and needs of their students” (MOE; Zeng & Zhou, 2013, p.272). For
improving active learning, schools are required to provide direction and support for teachers to create active learning opportunities for their students (Xue, 2007; Zeng & Zhou, 2013). The suggestion here is that the school system itself must play a large role in any attempt to incorporate active learning within the context of schooling.

(3) Exploring strategies for promoting active learning

Current research aims to clarify learning objectives, reform teaching methods, improve teacher-student relationships, and use variety of teaching approaches as the main ways to improve active learning (Lv, 2013; Shao, 2009; Xue, 2007). (See more detailed discussion of strategies to promote active learning in Section 2.4)

Along with the development and dynamic changes of active learning in China, teachers are currently expected to bear the responsibility of educating and preparing students to learn actively in the changing world (Wong, 2013). Promoting teachers’ professional development hence becomes essential, and it has been highlighted in the eighth NCR (MOE, 2001; Wong, 2013; Wan, 2013). Moreover, preparing high-quality teachers has been highly emphasized in China today (Li, 2006; Wan, 2013; Wen & Ren, 2010).

2.2 Professional development in China

The emphasis on teachers’ professional development has led to a variety of professional development opportunities after the eighth NCR (2001). Wang and Lu (2012) reviewed research on teachers’ professional development from 2001 to 2010 and concluded that there were three major types of professional development currently available to teachers in China. They are:
reflective teaching, action research and teacher training programs (Li, 2006; Wang & Lu, 2012). These were also considered as effective ways to help teachers incorporate active learning principles and skills into their existing pedagogical beliefs and understandings (Li, 2006; Wang & Lu, 2012). The following are the key characteristics of these three types of professional development (Wang & Lu, 2012, author’s own translation):

- **Reflective Teaching**: Reflective teaching is mainly comprised of teachers’ interpretation of their daily teaching experiences and student feedback (Richards & Lockhart, 1994). This type of professional development is normally conducted by individual teachers throughout the year. Richards & Lockhart (1994) stated that a reflective approach to teaching is “one in which teachers collect data about teaching, examine their attitudes, beliefs, assumptions and teaching practices, and use the information obtained as a basis for critical reflection about teaching (p.1).” Such critical reflections of teaching practices and students’ feedback are deemed to potentially trigger a deeper understanding of teaching, and contribute to one’s professional development.

- **Action Research**: This form of professional development has three basic types wherein an aspect of one’s teaching practice becomes the deliberative focus of systematic inquiry: individual (a teacher works on a personal inquiry), collaborative (a cohort of teachers come together to inquiry the the group), and school-wide/district-wide (a group of teachers engaged in institutional-level inquiry) (Li, 2006). Action research approach is a tool that is widely used to help teachers and schools to improve teaching practices. In the New
Curriculum Reform, action research is treated as a viable and realistic endeavor for transforming teaching (Li, 2006).

Action research provides teachers with opportunities to conduct research in their own classrooms. Teacher researchers continually ask questions about their teaching and seek solutions to instructional issues through various forms of evidence (for example, student work samples, formative assessments, observations, etc.) (Li, 2006; Somekh & Zeichner, 2009). Moreover, action research approach provides a platform for teachers to combine theory and practice, to identify problems and to eventually address problems that they have identified within their practice. Action research is both a research method and also a means of professional development for teachers. It has the potential to narrow the gap between scholars and teachers by bringing together theory and practice, to achieve teacher enhancement and to stimulate classroom reform (Li, 2006). Therefore, by systematically inquiring into teachers’ own practice, action research is regarded as an effective way for Chinese teachers’ to engage in professional growth (Li, 2006). Due to a significant amount of professional development involving the sharing of ideas and discussing the ways to implement these ideas to benefit student learning of the three forms of action research, collaborative action research has recently gained the highest level of attention in China (Wong, 2013; Wan, 2013).

- **In-service Teacher Professional Upgrading Programs:** Career long in-service teacher professional upgrading courses became compulsory in China after the implementation of the
eighth NCR in 2001 (MOE, 2001). The program is conducted respectively by education institutes and in-service teacher professional upgrading schools teachers at the local level (MOE, 2001). The programs are designed to provide continuing education opportunities for in-service teachers to learn new concepts of content and pedagogy, and to take on new roles after the New Curriculum Reform (Wan, 2013; Wang & Lu, 2012; Wen & Ren, 2010; Wong, 2013). It was fully implemented by Chinese Ministry of Education (MOE) and Ministry of Finance, and such implementation was an important effort to improve the overall quality of teachers. In order to secure teachers’ professional development, national, provincial, city, district and school level professional upgrading programs are offered for basic education teachers (Zeng & Zhou, 2013).

Basic education teachers need to take a specific number of professional upgrade courses each year to maintain their teaching certification (Wen & Ren, 2010). These courses are normally scheduled in the evenings or weekends to accommodate teachers’ working schedule. Most of the programs are purely lecture-based courses, while the rest are in the form of online courses. These programs create opportunities for teachers within a district or organization to learn something of common interest. Importantly, these programs are used to provide updated educational theories and instructional methods to all teachers that will help them, for example, to create active learning opportunities for their students, discuss pressing issues, and share teaching experiences. In-service teacher professional upgrade programs are deemed as the main channel for teachers to develop professionally.
Most teachers participate in all of these types of professional development. However, the result is varied (Li, 2006; Wang & Lu, 2012; Wen & Ren, 2010; Wong, 2013). In the past decade, few studies have examined the effectiveness of these three types of teacher professional development. Wang and Lu (2012) stated, among these three types, professional upgrade program were deemed to have the lowest effectiveness on teachers’ professional development after the eighth NCR. Among the factors contributing to programs’ low-effectiveness, “irrelevant/outdated content” was the most important factor (34%) (Wang & Lu, 2012; Wong, 2013). Moreover, for face-to-face courses, they failed to offer an effective and interactive platform to guide the teachers after the completion of the courses. For distance online training programs, teachers found it difficult to obtain high-quality training resources among all the platforms (Li, 2006; Wang & Lu, 2012). According to the findings of a few studies, personal issues professional attitudes, appraisals of feasibility, appraisals of meaningfulness, motivation, and desire for changing were the most significant factors in predicting the effectiveness of teachers’ professional development (Wong, 2013). Therefore, the other two types (reflective teaching and action research) that are closely related to personal issues, are becoming more and more popular in basic education (Wang & Lu, 2012; Wong, 2013).

As mentioned in the first chapter, after the eighth NCR, teachers still have difficulties in understanding “What is active learning?”, “Why is active learning important for students’ long-term development?”, and “What strategies could potentially promote active learning?”. Due to lack of basic understanding of active learning, the significance of active learning is usually
underestimated by basic education teachers (Yang & Yu, 2008). The following sections are an attempt to address those questions so that a holistic understanding of active learning is established for the reader.

2.3 Theory of active learning

2.3.1 What is active learning?

Simons (1997) described, “all learning is active in a certain sense, but some kinds of learning are more active than others” (p. 19). Therefore, defining active learning is the first question that must be answered in active learning research.

The definition of active learning was constantly changing throughout Western history (Ragains, 1995), and the definitions varied based on the characteristics of time, background, value, philosophy and the educational impacts.

As active learning was gradually developed as a concept, specific words and phrases were used commonly to capture the essence of active learning (Kyriacou, 1992), such as learning by doing, learning by experiencing, learning through activity, learning through communication, student-centered learning, peer collaboration, effective use of class time, inquiry learning, and engaging minds and cooperative learning (e.g., Bossert, 1989; Boyle, 2003; Brandes & Ginnis, 1986; Castro & Nowak, 2008; Damon & Phelps, 1989; Dennison & Kirk, 1990; Kyriacou, 1992; Prince, 2004; Ross & Raphael, 1990; Settles, 2012; Slavin, 1989).

Although it is difficult to provide a universally accepted definition, it is possible to put forth some generally accepted meanings, key qualities and characteristics that underlie active
learning (Prince, 2004). For example, in the book, *Active learning: Creating excitement in the classroom*, Bonwell & Eison (1991) provide the following definition:

Active learning can be defined as anything that involves students in doing things and thinking about the things they are doing. Although the term “active learning” has never been precisely defined in educational literature, some general characteristics are commonly associated with the use of strategies promoting active learning in the classroom:

- Students are involved in more than merely listening to teacher lectures.
- Less emphasis is placed on transmitting information and more on developing students' skills.
- Students are involved in higher-order thinking (analysis, synthesis, evaluation).
- Students are engaged in activities (e.g., reading, discussing, writing).
- Greater emphasis is placed on students’ exploration of their own attitudes and values. (p. 19)

Scholars argue that these terms describe active learning as any instructional method that strongly engages students in the learning process and develops their own thinking skills (Prince, 2004) while encouraging the frequency and variation of decisions students make in cooperation with a teacher. In short, active learning means combining exploratory thinking with the active use of thinking (Prince, 2004; Simons, 1997). Due to the combination of these two thought processes, active learning contrasts sharply with passive learning approaches, or what are sometimes called transmission or conduit models of learning (Bell & Kozlowski, 2008).

Unfortunately, due to lack of communication between researchers and teachers, active learning in China remains largely misunderstood (Ma, Jian, & Gu 2009). Moreover, the development of active learning in China is severely limited due to inadequate theoretical support for teachers and insufficient empirical feedback of active learning to researchers (Xing, 2005). One consequence is that high school classrooms have the lowest implementation of active
learning (Hao, 2011; He, 2003; Ma et al., 2009).

In articulating another definition for active learning, Ma et al.’s review of the active learning research from 2001 to 2009, suggests that active learning is:

- a process, which enables students to become actively involved in learning instead of passively “receiving” knowledge. The process includes reading, writing, discussion, analysis, synthesizing, problem solving and evaluation.

- Active learning affords students the opportunity to acquire a deeper understanding of course content and material.

- Active learning is a kind of teaching mode that helps students achieve comprehensive understandings toward knowledge through “doing”. (p. 70)

Although active learning is built on “doing”, many teachers associate active learning with non-intellectual factors such as motivation, confidence, desire for learning, and skepticism (e.g., Hao, 2011; He, 2003; Ma, 2009; Shao, 2009; Wang, 2005; Xing, 2005; Xue, 2007; Zhang, 2003). These factors emphasize the nature of the students’ mental experience, but ignore a number of constituent elements like involvement, cooperation and experience. Therefore, teachers’ understanding of active learning is insufficient and the emergence of this situation also highlights the challenges teachers face in acquiring theoretical support and knowledge from researchers (Xue, 2007).

2.3.2 Theoretical significance of active learning

In the beginning of 20th century historical education reformers (Montessori, Dewey, Freinet, Petersen, Parkhurst, Steiner, etc.) proposed new kinds of teaching theories where schools (e.g., Montessori schools, Freinet schools, Dalton schools, Jena schools, etc.) emphasized active
learning in various forms (Simons, 1997). Bonwell & Eison (1991) summarized the literature on active learning from these innovations and concluded that active learning can lead to better attitudes, improvements in students’ thinking and enhancements in students’ learning. Prince (2004) also claimed that, “the findings of active learning, such as the benefits of student engagement, are unlikely to be controversial” (p. 229). Moreover, research revealed that active learning enabled students to have a say in their education and afford the opportunities to be academically challenged, leading to heightened motivation and engagement (Kimonen & Nevalainen, 2005; Simons, 1997). The more students are motivated and engaged, the more the exploration of their own attitudes and values will be emphasized (Suherman et al., 2011). For these reasons, the authors suggest that students are more likely to be attracted to active learning than to traditional, more passive forms of learning. Active learning surpasses traditional lectures for retention in academic progress, promoting positive attitude and motivating students for further study (McKeachie, 1986; Prince, 2004; Simons, 1997).

Furthermore, active learning not only enables students to engage in meaningful learning activities but also encourages them to think about what they are doing (Bonwell & Eison, 1991; Prince, 2004). This means active learning has a twofold effect. It enhances students’ learning and also develops students’ skills like decision-making, thinking management and personal motivation. By becoming involved in the decision-making process of their learning, students could more efficiently facilitate the connection to their prior knowledge, their own needs and interests (Simons, 1997). Making connections during the active learning process enables students
to take responsibility in finding their own interests and motivations in the subjects or topics under study (e.g., mathematics). Therefore, for active learning, students have greater control over their own learning and learn how to learn, an increasingly important skill in the modern knowledge economy (Simons, 1997; Simons, Van der Linden, & Duffy, 2000; Suherman et al., 2011).

Previously, some believed that active learning was only for the elite, a special subset of intelligent students who were expected to actively engage in academia (Simons, 1997; Simons et al., 2000). For weaker students, only structured forms of teaching were required (Simons, 1997; Simons et al., 2000). According to Simons (1997), “During the eighties, however, this picture started to change. Several empirical studies have found that active learning and learning to learn and think are especially important for the weaker students” (p. 18). There are several reasons why active learning works well with students who find learning challenging. Primarily, active learning incorporates cooperative learning and individual thinking (Kimonen & Nevalainen, 2005; Prince, 2004). Active learning is by its nature an active method to get students involved and engaged. Both cognitive psychologists and effective teachers believe that students learn more by doing rather than by passively watching or listening (Felder, & Brent, 2007). When weaker students who find learning challenging engage and work cooperatively, they keep trying and are less likely to give up when they get stuck (Felder & Brent, 2007). This leads to improved work ethic, strengthened learning performances and improved morale (Simons, 1997; Simons et al., 2000).
2.3.3 Practical significance of active learning

Practical research on active learning focuses on the application of theoretical knowledge and answering the question, “Does active learning work?” (Michael, 2006; Prince, 2004). The majority of empirical results in published literature represent that there are large bodies of evidence from a number of different fields that support the effectiveness of active learning in the classroom (Michael, 2006; Prince, 2004).

In the practical field, a variety of methods fall under active learning. According to Michael and Modell (2003), the main teaching approaches to promote active learning include cooperative/collaborative learning/group work of all kinds, peer teaching, conceptual change learning, inquiry-based learning, problem-based learning, technology-enhanced learning and discovery learning. Enlightened by theoretical research, active learning approaches share common features, many of which emphasize the involvement of learners in the learning process and normally involve independent inquiry, collaborative learning, self-awareness of individual’s own learning and connections to the learner’s prior experience, current interests and future goals (Syah, Fitri, Yani, Qurnati, & Idris, 2011). However, Bell & Kozlowski (2008) noted:

The active learning approach is distinctive, in that it goes beyond simply “learning by doing” and focuses on using formal training design elements to systematically influence and support the cognitive, motivational, and emotional processes that characterize how people focus their attention, direct their effort, and manage their affect during learning. (p. 299)

Moreover, many practical researchers claim that active learning doesn’t just happen but instead, it requires careful planning, thoughtful implementation, and supportive classroom environment. Further, it requires a teacher’s knowledge of questioning techniques and strategies
for involving students in the classroom (Bell & Kozlowski, 2008; Michael, 2006). Their claims are based on eight gaps in the practice of education, with the gap between educational research and practice highlighted as the most serious one (Angelo & Cross, 1993; Bonwell & Eison, 1991). Therefore, to make active learning a predominant feature of classrooms requires teachers to become learners (or researchers) in order to reduce the gap between active learning research and practice (Bonwell & Eison, 1991; Michael, 2006). Otherwise, if active learning approaches are not implemented in a well thought out way, the outcomes do not meet expectations (Michael, 2006).

2.4 Active learning in mathematics

Since the British government commissioned the Cockcroft Report in 1982, there has been an increasing number of studies exploring the use of active learning in mathematics education (Smith, 1999) across the world. Promoting engagement, peer instruction, collaborative learning and encouraging communication are widely discussed in this research area and they can be divided into two main groups. These two groups are outlined below.

The first group mainly compromises straightforward studies by treating active learning as denoting particular types of teaching methods (e.g., Good et al., 1990; Kyriacou & Newson, 1991; Kyriacou, 1992; Röj-Lindberg, 2001; Salman, 2009). The aim of these studies is to explore different approaches, which are contrary to traditional mathematics teaching methods, to enable the learners to actively construct and develop their understandings of mathematical concepts (Röj-Lindberg, 2001). The approaches for acquisition of mathematics concepts and knowledge
place more emphasis on the process of understanding and experiencing rather than the products or solutions to given problems (Salman, 2009). Moreover, these approaches are designed to involve students in the learning process by giving them opportunities to feel and experience the mathematics teaching strategies (e.g., concrete material, activities, group discussions, real life related math problems) and thus develop their ability to apply what they have learned in the mathematics classroom.

As mentioned above, students do not spontaneously engage in active learning, they must be promoted to do so. Therefore the second group places emphasis on teachers’ professional development of active learning strategies and believes that teachers should take the responsibility for helping students develop an active relationship with mathematics learning (Buerk; 1994; Good et al., 1990; Kyriacou, 1992; Muijs & Reynolds, 2010; Rosenthal, 1995; Salman, 2009; Schoenfeld, 1988; Smith, 1999). This research focuses on answering the following questions: (1) what tasks or activities should be introduced to cultivate actively involved learners; and (2) what strategies should be used in class in helping students to develop an active relationship with math. Moreover, teachers who want to promote active learning normally adopt some new pedagogical approaches, such as ‘teacher as listener’, ‘teacher as researcher’ or ‘teacher as diagnostician’ (Muijs & Reynolds, 2010).

2.5 Active learning and relational understanding

Since the “The Full-time High School Education Mathematics Curriculum Standards” (“The Standards”) were issued in 2001 in China, considerable support for learning and teaching
with understandings was implemented (Zhang, 2004). Garegae (2007) claimed “the importance of mathematical understanding is construed as crucial by the entire world” (p. 232). Relevant research provided the mathematics community with a framework of what mathematics understanding could look like (Herscovics & Bergeron, 1988; Pirie & Kieren, 1994; Schroder, 1987; Skemp, 1976). Although the authors used different terms, their work promoted the same fundamental principles that mathematics understanding was a vital component of student success (Garegae, 2007).

As mentioned in Chapter 1, the dominant model for current instruction in China is based on what Skemp (1976) called “teaching mathematics for instrumental understanding: knowing rules without reasons” (p. 22) (Wang, 2011). The teaching style mainly focuses on ensuring the students obtain the ability to apply an appropriate remembered rule to the solution of a problem without knowing why the rule works (Skemp, 1986). Skemp (1976) proposed the term “relational understanding” and was the first person to distinguish relational understanding from instrumental understanding. The term relational implies connections between new and existing knowledge, various mathematical ideas and representations, and mathematics learned in school and everyday life (Beswick, 2005; Mousley, 2004; Skemp, 1976).

When active learning is stressed and valued, students are challenged to contribute to class discussion, which is said to lead to higher participation, engagement and achievement (Prince, 2004; Röj-Lindberg, 2001; Salman, 2009). Abilities that stem from active learning, such as the ability to connect methods and explain thought processes or represent ideas visually, are vital to
obtaining relational understandings (Skemp, 1986; Zhang, 2004). Moreover, research has shown that if students are given opportunities to actively engage in the learning process, they can make connections between different concepts of mathematics and develop relational understanding (Zhang, 2004; Zhang, 2005).

Concepts learned through active learning can be used flexibly, adapted to new situations, and used to generate new things (Prince, 2004). These are the most significant factors for gaining relational understandings (Skemp, 1986). Because when students are engaged in the active learning process, they can get inside the knowledge and see how it works and how different aspects of knowledge are related to each other (Smith, 1999). Consequently, active learners can develop relational understanding, which will remain for a long time and help them to learn, for example, meaningful mathematics content.

2.6 Strategies for promoting active mathematics learning in China

Students’ opportunities in promoting active relationship with mathematics are significantly shaped by classroom strategies and by the decisions teachers make as they enact curriculum and organize other aspects of instruction (Boaler, 2002; Boaler, 2006; Boaler, 2008; Hammond, 1998). As previously discussed, some of the main teaching methods to promote active learning are cooperative/collaborative learning/group work of all kinds, think-pair-share or peer teaching, conceptual change strategies, inquiry-based learning, problem-based learning, technology-enhanced learning, and discovery learning. The elements and characteristics of each approach are distinct.
Unfortunately, not every teaching approach or strategy related to active learning is compelling to Chinese students. Engaging teaching methods that fit within China’s unique student nature must be identified in order to promote active learning. This means teachers in China must select active learning strategies that respond to the specific characteristic of their students, the complicated culture of their school and the unique situation in China (He, 2003; Xue, 2007). There are three principles that have been commonly accepted as the basic criteria for choosing these suitable active learning strategies. First, educational leaders in China have maintained that the interactions in classrooms should be conducive to the cultivation of innovation and creativity (Sargent, 2009). A lack of student-student and student-teacher communication are the major barriers to the cultivation of innovation and creativity (Sargent, 2009). In response to this, strategies that could encourage interactions and engagement in classroom settings are recommended in the New Curriculum Reform. The document for the design and implementation of the New Curriculum reforms, MOE (2001, p. 14) stipulates teachers should select strategies that: “Promote active participation, the students’ desire to investigate, and their eagerness to use their hands.”

Second, teachers must examine the strategy and check if it has the potential to help Chinese students become more active learners. This is done by evaluating whether it is effective, for example, by introducing activities into the lecture or putting students into groups. Third, teaching procedures must focus on the core elements of each strategy, examine the effectiveness of every instructional technique, and adjust the strategy to meet the needs of classroom teaching.
Based on the context of China’s mathematics education and the implementation of these three basic principles, this review of the literature suggests that the following strategies used in Western countries would have the potential to meet the requirements of the eighth NCR.

2.6.1 Introducing activity into class

Salman (2009) stated:

Students learn both passively and actively. Passive learning takes place when students take on the role of ‘receptacles of knowledge’; that is, they do not directly participate in the learning process...Active learning is more likely to take place when students are doing something besides listening. (p. 20)

Consequently, introducing activities into math classes is essential to promoting active learning (Stern, 1997). Researchers claim that on the simplest level, active learning is the process of introducing activity into the traditional lecture (Prince, 2004). By incorporating meaningful learning activities, educational concepts are reinforced and students can actively engage in the learning process (Settles, 2012). Moreover, new educational environments and experiences are generated through the process (Voigt, 1998). According to Bonwell and Eison (1991), “Teachers can successfully overcome each of the major obstacles or barriers to the use of active learning and reduce the possibility of failure by gradually incorporating teaching strategies involving more activity into their regular teaching style” (p. 69). Two additional scholars, Aksoy and Link (2000), took this idea a step further and identified the statistical link between the amount of time spent on classroom activities and student grades. They determined that for each additional five minutes of classroom activity, students saw a one point increase in grades. In other instances, researchers found that introducing activity allows teachers to pause periodically, which improved
the effectiveness of lectures and students’ engagement (Prince, 2004; Ruhl, Hughes, & Schloss 1987).

Although numerous proponents of active learning applaud its success, China’s unique situation must be considered when verifying its effectiveness, such as the widespread acceptance of passive learning by students towards high school mathematics. Scardamalia and her colleagues (1989) concluded that passive learners tend to focus on surface features of an activity and seldom examine it in depth. This rushed approach to learning affects students’ ability to connect classroom knowledge to their lives and prevents them from acknowledging the need for revision, review or relevance (Bereiter, 1993). Normally, they treat the activities introduced in class in an additive fashion rather than transforming and enriching their existing knowledge strategies. Therefore, without guidelines for introducing activities into class, certain characteristics of passive (or immature) learners would prevent them from becoming active learners or life-long learners (Bonwell & Eison, 1991).

Therefore, characteristics associated with passive learning must be considered when choosing activities that intend to keep all students engaged in class (Prince, 2004). For instance, the activity introduced must be as realistic as possible, therefore allowing passive (or immature) learners to make connection between activity and real life (Grabinger & Dunlap, 2000). Each activity should also take into account students’ strengths, pre-existing knowledge, cultural tendencies and social skills (Wiggins & McTighe, 2006). In addition, activities should encourage students to regularly assess their personal understanding of knowledge, allowing students who
have a tendency to be passive learners to self-monitor and self-reflect (Michael, 2006).

Moreover, Wiggins and McTighe (2006) claim that only well designed activities achieve desired results. Simply introducing activity into math classroom fails to capture the important component of active learning (Prince, 2004). In “Understanding by Design” (Wiggins & McTighe, 1997), the authors emphasize that well designed activities that help students develop deep understanding of important mathematics ideas must be designed around important learning outcomes and aim to help students promote thoughtful engagements (Wiggins & McTighe, 2006; Prince, 2004). Thus, to keep Chinese students actively engaged in classroom lesson, while encouraging involvement in gathering information, thinking, and problem solving, teachers are required to make sustained efforts on designing and choosing the activity (Bonwell & Eison, 1991; Michael, 2006).

2.6.2 Small group cooperative learning

Johnson and Johnson (1988) concluded that there are three basic ways that students can interact with each other and connect over what they learn in the classroom. According to the research, Johnson and Johnson (1988) stated:

They can compete to see who is ‘best’; they can work individualistically on their own toward a goal without paying attention to other students; or they can work cooperatively in small groups with a vested interest in each other’s learning as well as their own. (para. 2)

Johnson and Johnson’s (1988) point is that these three interaction patterns are not equally effective in promoting active learning. Learning individually or competitively often creates negative interdependence, due to the patterns reliance on one person’s success (Curtis, 2006).
Compared with the other two interaction patterns, small group cooperative learning has shown more power in producing effective and active learning in classroom (Johnson & Johnson, 1988).

Small group cooperative learning takes place when 4-5 students collaborate to maximize both their individual and collective understanding of material (Braxton, Milem, & Sullivan, 2000; Johnson, Johnson, & Smith, 1991). Small group cooperative learning offers opportunities for students to discuss, debate and present their own thinking while listening to one another's perspectives (Springer, Stanne, & Donovan, 1999). Through content discussion, individuals can share attempts, even failure, within the group. Cognitive conflicts will arise, inadequate reasoning will be exposed, and enriched understanding will hopefully emerge (Springer et al., 1999). Davidson (1990, p. 52) concluded, “Small-group cooperative learning can be used to foster effective mathematical communication, problem solving, logical reasoning, and the making of mathematical connections.”

Over the past three decades, numerous studies have been published demonstrating the effectiveness of small group cooperative learning. These benefits include promoting greater student involvement in learning, higher achievement, enhanced confidence and interest, more cross-ethnic relationships, enhanced socialization among peers and more meaningful learning (Alrø & Skovsmose, 1998; Curtis, 2006; Good, 1990; Johnson et al., 1991; Kotsopoulos, 2007; Kyriacou & Newson, 1991; Kyriacou, 1992; Lehrer & Schauble, 2002; Nührenbörger & Steinbring, 2009; Palincsar, Stevens, & Gavelek, 1989; Prince, 2004; Scherer & Steinbring, 2007; Schoenfeld, 1988). Similar research also pointed out that small-group cooperative learning can
be a valuable method for promoting thinking and reflection, which is a pivotal strategy for active involvement of every student in the class, not just the “brave” students (Silberman, 1996). This forces students to step outside their comfort zone and try something they normally wouldn’t (Prince, 2004).

Although small group cooperative learning is an effective method to promote active learning and strengthen the development of communication, public speaking and critical thinking, it sometimes cause frustration and competition among students (Curtis, 2006; Gillies, 2003; Johnson et al., 1991). Because group members are equally responsible for the success of their group, they must be able to coordinate their decision-making and keep group processes on an academic level that is understood by each group member. Moreover, cooperation and active learning can only happen when groups are well formed so that students understand how they are expected to work together (Gillies, 2003; Johnson et al., 1991). Therefore, group structure is important for successful cooperative and active learning experience (Gillies, 2003).

Normally, there are two basic ways to form groups for effective cooperative learning. The first way is known as homogeneous ability grouping and the second way known as heterogeneous ability grouping (Lou et al., 1996; Prideaux, 2007; Saleh, Lazonder, & De Jong, 2005). In homogeneous ability groups, students are grouped according to achievement or academic ability (Prideaux, 2007). Contrary to achievement groups, heterogeneous ability groups include students of all academic backgrounds, abilities, and readiness levels (Prideaux, 2007). In 1996, Lou and other researchers reviewed twelve studies comparing the effects of homogeneous
ability grouping to heterogeneous ability grouping. According to the meta-analysis, they stated, “Low ability students learn more in heterogeneous groups, average-ability students achieve more in homogeneous groups, and high-ability students learn just as much in either group” (Lou et al., 1996; Saleh et al., 2005, p. 446).

Since homogeneous ability groups are comprised of students with similar academic needs, teachers can easily facilitate and adjust the instructions that determine the group’s progress (Lou et al., 1996). Since weaker students are grouped together, teachers are able to provide additional help, while stronger students are able to learn from each other and take classroom concepts a step further (Lou et al., 1996; Saleh et al., 2005). Research also indicates that when students interact with equal ability peers, they are more actively engaged in learning (Saleh et al., 2005). Without the ability gap, stronger students seldom complain about being held back by their slower teammates and weaker students rarely worry about being discounted or ignored in work sessions (Felder & Brent, 2007).

Heterogeneous ability groups include students of different academic backgrounds and abilities levels (Lou et al., 1996). Although discrepancies in academic ability are present, strong students assist weaker students with problems. Stronger students reinforce their understanding of the information through the process and weaker students acquire one on one insight into material (Felder & Brent, 2007). This interaction between students of varying levels encourages students of all levels to ask questions and further develop social skills, as well as master the educational concepts (Bonwell & Eison, 1991).
2.6.3 Peer teaching

One aid to gaining active mathematics learning is through peer teaching. Peer teaching is a method of empowering students as teachers in a classroom setting. Through this approach, students learn by teaching (Whitman, 1988). During the peer teaching process, knowledge is constructed by both peer teachers and peer learners, then exchanged in the classroom (Curtis, 2006). Peer teaching is known as an effective way to learn mathematical knowledge (Curtis, 2006; Whitman, 1988). Because during the peer teaching process both peer teachers and peer learners are able to benefit in the learning process (Briggs, 2013; Fan & Yeo, 2007; Fines, 2008; Whitman, 1988). It is also a beneficial way for teachers to gauge students’ understanding of material and thus teachers are able to make more informed instructional decisions (Fan & Yeo, 2007). Furthermore, peer teaching is also an effective approach for strengthening each student’s communication skills (Curtis, 2006; Fan & Yeo, 2007; Whitman, 1988). While verbally sharing ideas, clarifying understanding, and expressing mathematics understanding in their own words, students’ speaking skills are improved.

Instead of treating the knowledge as given from teacher to student, the peer learner is more likely to see the peer teaching process as a type of interaction in which both peer teachers and peer learners are actively involved (Fines, 2008). During the peer teaching process, peer learners engage by exploring ideas and concepts and maintain teaching levels by negotiating the meanings and connections of concepts with each peer teacher (Curtis, 2006; Whitman, 1988). Therefore, peer learners develop the knowledge for understanding mathematics and become
actively engaged in the learning process (Briggs, 2013).

Peer-teachers benefit through the preparation process. In other words, when peer teachers review and organize the material they are responsible for teaching, they gain a deeper understanding of the mathematical concepts and ideas (Briggs, 2013; Whitman, 1988). Peer teaching operates on a different cognitive level than traditional teaching from a teacher. This is because students only recently learned the nuances of the concept they are teaching. Their understanding of the concept is on a much more shallow level, lacking holistic understanding (Fines, 2008). This provides room for a trial and error process and allows students to self-correct while they master the information. This elevates student engagement and strengthens individual confidence to share their understanding (Curtis, 2006; Fines, 2008; Whitman, 1988).

In general, peer teaching has potential to give students opportunities to comprehensively learn mathematics. Since peer teaching is based on students’ interactions with each other, it is an effective strategy to help students become active learners and to exchange math concepts in their own words (Silberman, 1996). The peer teaching process can also help both peer teachers and peer learners accept the idea that mathematics is about questioning, conjecturing, trial and error (Curtis, 2006). This suggests peer teaching can effectively drive students to engage in critical thinking to produce deeper learning outcomes (Landers, 2013).

According to Gartner, Kohler, & Riessman (1971), “It has long been obvious that children learn from their peers, but a more significant observation is that children learn more from teaching other children” (p. 1). In recent decades, many researchers have explored the concept
and the importance of peer teaching and believed that a subject is truly mastered only when a student is able to teach it to someone else (Cuseo, 1997; Goto & Schneider 2010; Silberman, 1996; Whitman, 1988). Based on the research results on peer teaching, Briggs (2013, para, 4) acknowledged the following five statements as the main benefit of peer teaching:

- Direct interaction between students promotes active learning.
- Peer-teachers reinforce their own learning by instructing others.
- Students feel more comfortable and open when exchanging ideas with a peer.
- Peers and students share a similar discourse, allowing for greater understanding.
- Teachers receive more time to focus on understanding students’ thinking.

While peer teaching is important for successful active mathematics learning, it is enhanced when students are taught the needed teaching skills to promote a sharing and caring environment in the classroom (Gillies, 2003; Johnson & Johnson, 1988). The identified skills that facilitate and effect peer teaching include: thinking through each step before teaching; expressing thought processes explicitly during teaching; acknowledging peer learners’ ideas and considering their perspective on issues after teaching; responding patiently to peer learners’ questions; resolving conflicts democratically (Gillies, 2003; Johnson et al., 1991; Whitman, 1988). Scholars agree that students must be taught each of these skills and provided with adequate opportunities to use them. Learning by doing allows students to connect classrooms concepts to their personal lives while simultaneously connecting to their fellow classmates. Classroom acceptance reinforces peer teaching and learning as a positive experience and helps students realize that peer support can be more effective than individual competition (Gillies, 2003; Johnson & Johnson, 1988).
2.7 Active learning principles as applied in this research study

Active learning principles that are mentioned in the eighth NCR documents were employed as a theoretical framework in this study to guide collaborating teachers creating active learning opportunities for their students. Principles related to mathematics teaching, teachers’ professional development and relational understanding were used by teachers during the process of creating active learning opportunities. Moreover, principles of active learning helped teachers address challenges and choose appropriate strategies. This study also extends the use of the principles to providing guidance and sources for teachers to effectively plan and implement lessons.

The methodological framework in this study also draws upon principles of active learning in order to design a collaborative action research. Teachers’ understanding of their changed practices with their participation in the study could thus be studied. What is foregrounded is how lessons are thoughtfully and carefully designed under the guidance of active learning principles.

Consistent with the literature reviewed above, we conducted our study with the aim to understand how high school mathematics teachers in China could create active learning opportunities for their students. This helped direct our attention as we conducted an action research study within the context of teachers’ own classroom. Our study centered upon helping teachers improve their practices, collaboratively overcome the challenges they face and eventually create active learning opportunities for their students. It also considered the effects of broader school factors and the contexts in which different approaches were enacted.
3 Methodology and Methods employed

In this chapter, the action research approach is first described in order to explain this study’s implementation. Methods, data sources and data analysis process are then outlined. Subsequently, my role in this study is discussed.

3.1 Theoretical framing of action research

3.1.1 What is action research?

In this study, action research was used in order to better understand how secondary mathematics teachers in China created active learning opportunities for their students. John Elliott (1991) defined action research as:

…the process through which teachers collaborate in evaluating their practice jointly; raise awareness of their personal theory; articulate a shared conception of values; try out new strategies to render the values expressed in their practice more consistent with educational values they espouse; record their work in a form which is readily available to and understandable by other teachers; and thus develop a shared theory of teaching by research practice. (p. 105)

According to this definition, action research study seeks to document the context, explore strategies, change processes, and eventually improve teaching practices (Young, Rapp, & Murphy, 2010). In other words, action research investigates how issues or problems are solved. This can include analyzing teaching methods, examining guidelines for finding solutions or investigating strategies for improvement (Popplewell & Hayman, 2012). In fact, action research could bring about desirable changes and produce knowledge that can be observed in the investigated classes. Action research is a work in progress, a cyclical process of “think-do-think” research and change (MacNaughton & Hughes, 2008). According to MacNaughton and Hughes
In an action research, we think about what we do at present, then we do something to create change, then we think again about what we’ve done and its effects. Our thinking informs our practice; and our practice informs our further thinking. (p. 1)

3.1.2 Steps in the action research

As a research paradigm and methodology, action research is multi-faceted and there is no definitive way of conducting it (Goodnough, 2011). Eileen Ferrance’s Action Research Cycle (2000), which combines numerous approaches, was adopted in this study and Figure 3.1 illustrates the process. Ferrance’s action research cycle was adopted for three main reasons. The first reason is to reduce false starts and frustrations. Teachers faced varied challenges in promoting active learning prior to the study, which means they would have their own questions they wish to investigate. However, it is important to limit the questions to the confines of teachers’ daily work. Therefore, the first stage of the cycle should be careful identification of problem area, which will limit false starts and frustrations (Ferrance, 2000). Second, it is important to help teachers learn about themselves and their students in a meaningful way. The following steps of the Ferrance cycle are data collation, organization and interpretation. These steps could help to strengthen the image of teacher as researcher. More specifically, data collection could decide which action needs to be taken, data organization could help to review the data holistically, and data interpretation could help teachers articulate important elements and themes. Last, action and reflection need to be accomplished in order to help teachers overcome the challenges they face and to eventually create active learning opportunities for their students. Ferrance’s cycle meets this need. Based on the information from data collection and
interpretation, teachers were expected to design an action plan, which would help them to change their teaching practice and study that change. More importantly the action plan has the potential to help teachers generate new strategies to promote active learning. The generated new action steps and reflections from the results of previous action plan gave teachers’ opportunity to engage in the professional learning.

Figure 3.1 Action Research Cycle. From “Action research,” by E. Ferrance, 2000, p. 9. Copyright 2000 by the Brown University Press.

According to the adopted action research cycle, the process of the action research project involved: questioning, planning, implementing, data collecting, data analyzing, reflecting, adjusting, and synthesizing. The step-by-step process in fact overlapped and recurred. Therefore, in order to help teachers create active learning opportunities for their students, we followed the following 5 collaborative steps in the study (Rock & Levin, 2002):

1. Identification of a question to be researched.
2. Formation of a strategic plan of action that will improve teaching and learning.
3. Collection of data in various forms to evaluate the effects of the strategic action plan.
4. Reflection upon the results of the strategic action plan to make sense of the processes, problems, issues, and constraints.
5. Creation of new action steps to be taken based on what was learned.
3.1.3 The role of action research in education

It is believed that action research can make a unique contribution to educational reform (Somekh & Zeichner, 2009). Action research is now widely used in school-based curriculum development, professional growth, and school improvement (Popplewell & Hayman, 2012). Importantly, action research is deemed to be the key method for teacher’s professional development and school change in China. That’s mainly because action research encourages teachers to welcome educational reforms that foster action and progress instead of accepting the status quo (Mills, 2003). Additionally, it could largely help teachers to reflect on personal challenges in the classroom and systematically locate logical solutions (Popplewell & Hayman, 2012).

During the educational action research process, expert research knowledge and local knowledge are combined. Consequently, the interpretation of the results and the design of actions lead to a deeper and more comprehensive understanding of “local stakeholders” (Brydon-Miller, Greenwood & Maguire, 2003, p.17). Therefore, action research is treated as an effective practice, able to produce more “valid” results than conventional research in education (Brydon-Miller, et al., 2003). Moreover, the boundary-crossing nature of action research makes it a particularly well-suited methodology for educational transformation in the 21st century (Somekh & Zeichner, 2009). Action research creates possibilities for change, improvement of practice, and a shift in consciousness (Pedretti, 1996).

To further characterize the role of action research in education, research goals must be
identified. Raymond and Leinenbach (2000) reviewed studies from the 1980s to 2000 and found six basic goals of educational action research. These goals include, “to bridge the gap between scholars and teachers; to provide opportunities for teacher enhancement; to stimulate classroom reform; to enhance the professional status of teaching; to improve teaching and learning; to generate theory and knowledge” (Raymond & Leinenbach, 2000, p. 285). It is important to realize that conducting educational research will not necessarily meet all of these goals. Action research requires careful planning, thoughtful implementation, a supportive school environment, in addition to a teacher’s deep understanding of how to conduct action research (Hewitt & Little, 2005).

3.1.4 Collaborative aspect of action research

Teachers’ sharing of practices and knowledge has been acknowledged and valued as part of their professional development (Tan, 2011). An increasing amount of literature highlights the importance of teachers’ collaborative working (e.g., Avgitidou, 2009; Bruce, Flynn, & Stagg-Peterson, 2011; Frankham & Howes, 2011; Goodnough, 2011; Tan, 2011; Young, et al., 2010). These studies emphasized collaborative reflection and inquiry. According to Avgitidou (2009), by sharing ideas, planning collaboratively, and critiquing each other’s ideas, the collaborative environment among teachers led them to new ways of enhancing professional development.

Within a collaborative action research context, teachers participate as researchers and work together to acquire greater depth in interpreting curriculum; to enhance pedagogical content
knowledge; to investigate solutions to classroom-based problems; to construct and build up theories; and to form and re-form beliefs, goals, and practice in relation to teaching (Avgitidou, 2009; Bruce, et al., 2011; Frankham & Howes, 2011; Goodnough, 2011; Tan, 2011; Young et al., 2010). The collaborative culture enables teachers to share and discuss ideas and resources, which are absolutely central to teachers’ daily work (Tan, 2011).

Collaboration within an action research context has the potential to encourage reflection, and a kind of joint reflection about the relationship between processes and products can occur (Elliot, 1991). Importantly, when teachers engage in reflection or conversations about their practice with others, they can learn from each other and enhance problem solving and creativity by diverse groupings (Tan, 2011). This collective approach to the improvement of classroom practice is becoming the foundation of a creative culture of collaborative action research (Avgitidou, 2009).

3.1.5 Teachers as researchers

Earlier research has long recognized the necessity of teachers-as-researchers in school settings (Tan, 2011). Through action research approach, teachers can conduct research in their own classrooms to inquire and improve their teaching practices (Tan, 2011).

In an action research approach, teacher researchers decide what to study. The research question emerges from teachers’ own curiosity, with roots in some aspects of classroom life. In this study, participating teachers first identify a research question (such as: “What kind of activity has the potential to help students become more active learners?”, “How to engage girls in
small group cooperative learning?”, and “How to face the challenges emerged from peer teaching?”), and then, they will make a strategic plan of action to answer the question.

In order to answer the questions, teachers collect their own data in various forms to study the effects of the strategic action plan. Data collection is an important step in verifying the effectiveness of the strategic action plan. Multiple sources of data were used to better understand the scope of happenings in the classroom. MacLean’s and Mohr’s (1999) collecting classroom data were introduced to the participating teachers in order to help them collect data.

Classrooms are full of data, although what happens there is not often thought of as research. You collect data whenever you grade students’ papers or listen carefully as a student struggles to talk through a problem. You are also collecting data when you write in your research log — recording field notes, classroom observations, and reflections — and when you write and revise your research question. You will probably, in the midst of your research, recognize happily that everything is data about something. You are surrounded, immersed, inundated. (p. 36)

In addition to above opportunities to record data, there are many other strategies such as: observation, students interview, and students work sample collection. These strategies were widely used in this study by participating teachers in their role of researching their practice.

3.2 Method

3.2.1 Context

This action research study was conducted in Renhe High School, China. There are three main reasons behind the choice of this school for the study. First, Wuhan is a large industrial urban city in central China with a mostly working-class demographic. Therefore, the students at Renhe High School are representative of Wuhan and urban Chinese working class youth. The
second reason is its accessibility. I had worked as a mathematics teacher at Renhe High School for six years, from 2005 to 2011, and therefore I had preexisting relationships and contacts there. It is also worth mentioning that the principal of Renhe High School is my father. Therefore, it would be easier for me to communicate with the teachers and upper powers at Renhe High School. All these could help me to conduct the research more smoothly. Last but not least, the principal, administrators, and teachers at this school are passionate about trying new methods to improve teaching. The principal always supports teachers’ professional development. For example, Renhe High School uses a tradition called “Collective Lesson Preparation” (CLP). CLP means all the teachers who teach the same grade and same subject form a team and conduct weekly team meetings. During the one-hour CLP meetings, teachers are encouraged to share their classroom experiences, findings, and practices. CLP also provides opportunities for teachers to work together to find solutions to classroom challenges, while also promoting their professional growth.

Renhe High School was established in 1930 and is located in the Qingshan district. There are eight high schools in this district and Renhe High School is ranked in the second level among them (right after two top-level high schools). This school has 27 classes, approximately 1,220 students and 107 teachers. Based on the policy of the high school entrance examination, held by the Wuhan Education Bureau, grade 10 students at Renhe High School are recruited from 15 middle schools throughout the Qingshan district. Recruitment criteria depended on students’ high school entrance exam scores. There are nine classes in grade 10, which are numbered from 1 to 9
(such as: class 1, class 2 and class 3). In grade 10, after every semester-period examination, students will be re-grouped into different level classes based on their academic performance (tests score). This year, class 6 is assigned as the top-level class and the students in this class are who ranked from 1 to 36. There are six second-level classes (class 1, class 2, class 3, class 4, class 5, and class 9), and these classes’ academic levels are basically the same. Students who ranked from 37 to 300 are re-grouped into these classes. Class 7 and class 8 are the bottom level classes. Students who ranked after 300 are in these two classes.

3.2.2 Participants

The study involved three grade 10 mathematics teachers: Lee, Sue and Hen (see table 3.1). In addition, the teachers’ students (128 students in total) also participated in the study (Lee’s class-6 had 36 students, Sue’s class-5 had 45 students, and Hen’s class-7 had 47 students). The selection of the teachers was based on availability. The potential benefits of participating in the research were also presented to the teachers before the study began. The benefits included the potential opportunities for teachers’ professional development; the possibilities of helping students develop active relationship with mathematics, and a small honorarium for their increasing workload. It is important to note that the financial bonus for teachers’ participation will not affect the study. Because all the participating teachers stated that the reason they wanted to participate in the research is only because they were eager to improve their teaching. They even stated, “The bonus for participation is only equivalent to half a month of salary, so we don’t think it could be our motivation to join the team”.

Table 3.1: Teaching experience of the participating teachers.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Total no. of years in teaching (yrs)</th>
<th>No. of years teaching in Renhe High School (yrs)</th>
<th>No. of times chosen topic was taught before (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee</td>
<td>26</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>Sue</td>
<td>19</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Hen</td>
<td>21</td>
<td>17</td>
<td>6</td>
</tr>
</tbody>
</table>

3.2.3 Implementation of the action research

With the consideration of the “Action Research Cycle” (in section 3.1.2) and obstacles of the study (e.g., lack of contextual understanding of active learning among the participating teachers), I divided the study into three phases: “Participating in the active learning workshops”, “Creating active learning opportunities” and “Sharing reflections on experiences”. The research steps followed the arrangement of the research team meetings. The research team members are three participating teachers, the principal of Renhe High School and me. The research team meetings (one meeting per week) were based on the math team tradition of Collective Lesson Preparation (CLP) mentioned above. Introducing CLP into the study provided an opportunity to capitalize on a preexisting and successful medium that grouped teachers into clusters to help them learn from each other (McTaggart, 1991). Importantly, the team meetings served several purposes: to assist teachers in understanding the nature of the action research project, to support teachers to create active learning opportunities for their students, to provide a forum for sharing success, challenges and understandings of active learning during the action research planning and implementation, and to foster individual and group reflection (Goodnough, 2011).
Moreover, in Renhe High School, every teacher needs to write reflections after daily teaching. The “Teaching Reflection” (TR) is intended to help teachers identify and articulate new understanding(s) about “what’s going on” in the classroom. In this study, the tradition of writing daily TR was also stressed to help teachers keep records of the students’ and their own development within the project.

Daily TR follows the intentional and systematic nature of teachers’ research on creating active learning opportunities for students. In this project, every teacher’s daily TR was data that was collected and analyzed for this study. In addition, every teacher’s daily TR did not focus on proving their ability through research, but rather describing changed understandings that emerged with their participation in the action research group (Anderson, 2009). TR was also introduced to facilitate an exploration of the implications for classroom practice. Questions, such as what they had tried, what challenges and successes they encountered, and why a new practice or strategy would be embraced or rejected following the active learning creating process, were discussed in every teacher’s daily TR.

Teachers all agreed to give the research team full access to their daily TR and they were aware that their TR would be shared in the research team meetings. The time line of the research team meetings is provided below (Table 3.2).

**Table 3.2:** Time line of the research team meetings

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>1</td>
<td>6/Jan</td>
</tr>
<tr>
<td>No.</td>
<td>Time</td>
<td>Themes</td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>3</td>
<td>17/Feb</td>
<td>Reflections of the book “Active Learning: 101 Strategies To Teach Any Subject”</td>
</tr>
<tr>
<td>4</td>
<td>20/Feb</td>
<td>Examples of active learning (Videos)</td>
</tr>
<tr>
<td>5</td>
<td>21/Feb</td>
<td>Reflections of “The Standards”</td>
</tr>
<tr>
<td>6</td>
<td>26/Feb</td>
<td>Crafting of students pre-lesson test</td>
</tr>
<tr>
<td>7</td>
<td>3/Mar</td>
<td>Review student pre-lesson test; Plan the first research lesson, “Law of Sines”</td>
</tr>
<tr>
<td>8</td>
<td>5/Mar</td>
<td>Share the TR about “Law of Sines”; Plan the lesson “Law of Cosines”</td>
</tr>
<tr>
<td>9</td>
<td>11/Mar</td>
<td>Share last week’s TR; Plan research lesson “The Application of The Law of Sines and Cosines (I)”</td>
</tr>
<tr>
<td>10</td>
<td>17/Mar</td>
<td>Share last week’s TR; Plan research lesson “The Application of The Law of Sines and Cosines (II)”</td>
</tr>
<tr>
<td>11</td>
<td>25/Mar</td>
<td>Share last week’s TR; Plan research lesson “Sequence”</td>
</tr>
<tr>
<td>12</td>
<td>1/Apr</td>
<td>Share last week’s TR; Plan research lesson “Finding the general term of a recursive sequence”</td>
</tr>
<tr>
<td>13</td>
<td>8/Apr</td>
<td>Share last week’s TR; Plan research lesson “Inequality”</td>
</tr>
<tr>
<td>14</td>
<td>15/Apr</td>
<td>Share last week’s TR; Plan research lesson “Inequality Word Problems”</td>
</tr>
<tr>
<td>15</td>
<td>6/May</td>
<td>Share last week’s TR; Plan research lesson “Linear Programming”</td>
</tr>
<tr>
<td>16</td>
<td>13/May</td>
<td>Crafting of student post-lesson test</td>
</tr>
<tr>
<td>17</td>
<td>20/May</td>
<td>Review student post-lesson test</td>
</tr>
<tr>
<td>18</td>
<td>21/May</td>
<td>Reflections on action research</td>
</tr>
</tbody>
</table>
**Phase 1: Participating in the active learning workshops.** Participants attended five research team meetings over the course of five weeks, which included one research introduction and four active learning workshops. One teacher interview and one student pre-lesson test were conducted during this time. Due to the Chinese New Year and winter vacation, phase 1 was divided into two parts. The first part ran from January 6 to January 21, 2014 and the second part ran from February 17 to February 28, 2014.

**Meeting 1: Introduction to the study (January 6, 2014)**

Research began with an introduction to the study and its proposed timeline (January to May, 2014). During this meeting, teachers were informed of the study’s purpose and objectives, including the overarching goal of the research and reasons to adapt teaching approaches, active learning was defined and the importance of active learning for students’ long-term development was addressed. As mentioned in section 3.1.4, I also explained how the teachers would be involved in the study, what types of data would be collected, and how teachers would perform the data collection.

Considering examples from the past (Bruce, et al., 2011), where action research may have been dominated by ‘outsiders’ including the principal and university researchers, my role and the principal’s role were explained during the initial research team meeting. My job was to facilitate discussions, organize and record meetings, and provide supporting materials related to the research. My role in the study will be fully discussed in section 3.5.
During the study, the principal’s role would be to act as a “critical friend” (MacNaughton & Hughes, 2008, p.146). This means that the principal would support the participating teachers’ thinking, but also critique it and challenge whether the strategies teacher employed were the most effective choice. The aim of this “critical friend” was to help teachers become “critically knowing” and encourage them to create active learning opportunities for their students through their own teaching while also promote long-term teacher development (Kember et al., 1997).

In order to cultivate a cooperative and friendly environment in school, the principal has built a less-formal, more friendly and collegial relationship with teachers. Therefore, due to the personal friendships that existed between the research team members, the role of the principal was primarily as a “friend” who provided advice to his fellow colleagues. This arrangement would allow teachers to be accepting of the critical friend, instead of impeding the development of reflective and learning capacity through the principals’ power and authority (Kember et al., 1997). Moreover, the “critical friend” would listen, in addition to being flexible and open to new ideas.

Meeting 2, 3, 4 and 5: Active learning workshops (January 7-24th and February 17-21, 2014)

Originally, the participating active learning workshop was only scheduled to last for one week. However, unexpected requests were raised during the study, because the three participants expressed interest in receiving more guidance on how to promote active learning. The New Curriculum Reform had been in effect in Wuhan for 11 years since 2003. However, although all three participants were quite familiar with “The Standards”, they had experienced difficulties in
implementing “The Standards” into their teaching. Therefore, the active learning workshop was extended to accommodate this request and lasted for four weeks after the research introduction.

The four active learning workshops were designed to help the teachers understand active learning principles, the potential strategies to promote active learning, and “The Standards” mentioned in the New Curriculum Reform. In order to achieve these, I showed teachers the videos of typical active learning classrooms in Western countries (such as the Third International Mathematics and Science Study video), as well as Japan and China. I also provided relevant books, handouts and papers about how to promote active learning. During these workshops, the teachers were able to address their confusions and discuss the materials with each other and me.

Moreover, the workshops often provided potential activities and strategies for teachers to create active learning opportunities for students. Teachers were encouraged to be critical of the effectiveness of these example activities and strategies. Moreover, teachers were encouraged to express their thinking toward the questions, such as “Would the example be suitable for their students?” and “How to adapt the activities to their classrooms?”. Therefore, the criteria and answers behind the example activities fostered an environment for participating teachers to develop a comprehensive understanding of active learning.

The first research lesson in phase two was also discussed, and teachers agreed to choose “Law of Sines” as the first research lesson. From their experience, few students were able to acquire deep understanding of “Law of Sines” in the past, and relied on memorization to understand the law. Although memorization helped students use the formula correctly, it did not
allow students to understand it relationally. Therefore, the teachers chose “Law of Sines” as the first research lesson and hoped students could obtain a deeper mathematical understanding of it, which might have positive impacts on solving complex problems in the future.

Administration of the first set of teacher-interview

The first set of semi-structured teacher interviews (Appendix A) was conducted on February 25, after four active learning workshops. The interview focused on the participating teachers’ thoughts toward current teaching approaches, their attitudes, understanding and expectation toward active learning strategies and the action research project.

Meeting 6: Crafting of student pre-lesson test (February 26, 2014)

During this meeting, we also prepared a student pre-lesson test (Appendix B). The pre-test aimed to help participating teachers understand students’ thoughts on mathematical problem solving. The materials for crafting the test were provided by participating teachers, and they thoroughly discussed every chosen problem. Three participating teachers (Lee, Sue and Hen) all chose the same time (Friday afternoon on February 28, 2014) for their students to take the test. They thought this would allow them to analyze the results over the weekend.

The test lasted 40 minutes and 128 students participated. On February 27, 2014, the day before taking the test, I prepared a 30-minute presentation for the 128 students. The presentation’s purpose was to inform students about the research, describe the reasons behind promoting active learning and explain any potential benefits and concerns.
Meeting 7: Review student pre-lesson test (March 3, 2014)

During this meeting, teachers were granted the entire hour to examine students’ scripts and prepare an analysis of the students’ results. Teachers were encouraged to express their opinions and findings of the pre-test results by analyzing the main problems students struggled with and determining which strategies have the potential to solve students’ existing problems. This meeting was intended to provide teachers with an opportunity to discuss their thoughts on their teaching and students’ learning. The research team provided guidance based on the pre-test findings and results.

**Phase 2: Creating active learning opportunities.** This part of the study took place for two months, from March 3 to May 9, 2014. During this time, participating teachers introduced the active learning approaches into their classrooms in an attempt to create active learning opportunities for their students. Nine research team meetings were also conducted.

Meeting 8-15: Preparations and implementation of research lessons (March 4, 2014 - May 9, 2014)

All the research lessons during the two-month research period were prepared by a sequence of action research steps (in section 3.1.2). There were three steps that every research team meeting followed during the two months. The first step involved teachers sharing their last weeks’ daily TR. The sharing was mainly for teachers to report the successes of their teaching, findings and challenges, as well as to evaluate students’ feedback. Based on the data collected from observations, the “critical friend” and I also pointed out areas that could be improved and
highlighted effective teaching approaches in this step. The second step aimed to identify and solve problems, both from teachers and students, based on the findings from step one. Lastly, the third step looked at ways to incorporate revisions and feedback from the first two steps into the next week’s lesson plan in order to improve and promote active learning. The inclusion of new activities and strategies was discussed in the meetings directly preceding the next week’s lesson. Feelings, attitudes and thoughts about research lesson implementation were also shared during these meetings. Therefore, the weekly research team meetings during this phase were provided for teachers to:

1. share their previous week’s classroom experiences, practices, findings, difficulties and student feedback;
2. examine teacher’s own teaching through extensive questioning and dialogue;
3. identify areas for improvement and highlight effective teaching approaches;
4. identify problems and find solutions to classroom challenges;
5. collaboratively plan the research lessons for the next week.

**Phase 3: Sharing reflections on experiences.** This consisted of three research team meetings over the course of one week, from May 12 through May 21, 2014.

**Meeting 16: Crafting of student post-lesson test (May 13, 2014)**

The post-lesson student test (Appendix C) aimed to reflect students’ mathematical thinking and reasoning. It served as a way for participating teachers to evaluate the previous two months of teaching and provide a comparison between the pre and post-lesson tests. Through the
post-test and the comparison, teachers were able to examine the extent of mastery knowledge and to gain findings from the test to improve their teaching. The resources for the post-lesson test questions were also provided by participating teachers. Again, the test lasted for 40 minutes and featured the same question style as the pre-lesson test. The same 128 students participated the post-test on May 16, 2014.

Administration of student-interview and the second set of teacher-interviews

Semi-structured student and teacher interviews (Appendix D) were conducted after the 16th research team meeting (from May 13 to May 19, 2014). All the interviews were conducted by me in Mandarin.

The student interview aimed to help teachers comprehend students’ attitudes toward the previous two months’ teaching. The student interviews also tried to explore how students perceived the research lessons and determine how comfortable they felt with the new teaching strategies. Considering that students might be afraid to express or could not fully express their opinions to their teachers, all the student interviews were conducted by me. During the interview, each student was asked to share opinions about the previous two months’ research lessons. The students were reassured that their responses would be confidential and, in any discussion with the teachers, that anonymity would be assured.

I interviewed five students from each class. Selection criterion was random and followed a “first come, first served” principle. The interviews were video recorded. I analyzed the interviews alone and shared the findings with teachers in the last research team meeting.
The second set of teacher interviews occurred on May 19. This set of teacher interviews was intended to answer the guiding research question “How are teachers’ understandings of their practice changed with their participation in the action research group?” During the interview, teachers were encouraged to provide feedback on the participation in the action research. In addition, teachers were asked to share their opinions on whether they expect that their teaching and learning will change after participation in the research.

Meeting 17: Review student post-lesson test (May 20)

Repeating the process used in reviewing student pre-lesson test, this meeting also encouraged teachers to express their opinions and findings of the post-test results. The comparison between pre-test and post-test results were intended to reveal a deeper understanding of the students’ mathematical thinking and teachers’ teaching.

Meeting 18: Reflection on action research (May 21)

This meeting comprised two parts. During the first part, results from the student interviews were shared. This aimed to help teachers gain a holistic understanding of their teaching by providing them with useful feedback and highlighting students’ beliefs or attitudes toward teachers’ teaching approaches. The second part of the meeting focused on sharing every teacher’s final report, which was a summary of teacher’s findings during the second phase. Moreover, in this meeting, teachers were encouraged to reflect on the question, “What did we learn from the research?” I guided the participating teachers in answering this question from three different directions: students’ engagement, students’ attitude toward mathematics learning, and students’
understandings of the knowledge they learned during these two months.

3.3 Data Collection

Two levels of data were obtained in this research study. Data collected by the teacher researchers included evaluation of students’ pre- and post- tests, observation and work sample data, and daily TR. Data collected by me included classroom observations, research team meetings, and teacher-interviews.

Classroom observations began on the first day of the research lesson tryout and occurred once a week for each class. The critical friend (the principal) and I observed the research lessons together. Field notes and photographs were taken during each observation. Observations had a two-fold purpose. Firstly, the observations were intended to follow students’ interactions, engagement, and involvement over time. Secondly, the observations focused on the teacher’s role, activities taking place in the classroom, as well as strategies introduced to promote active learning. Through these observations, a shared knowledge and understanding of what went on in the classrooms was gradually gained among the teachers. My presence in the classroom also provided opportunity for me to discuss with the teachers what I observed in the classroom. To provide a physical sense of the data collected during observation, some photograph samples I took are shown below (Figure 3.2).
The action research team met once a week and 18 times in total between January 6, 2014 and May 21, 2014. The time line of the research team meetings is provided above (Table 3.2). All meetings were videotaped. Field notes were written during and after each research team meeting to further elaborate the tapes. To provide a physical sense of the data collected during research team meetings, a research team meeting photograph sample is shown below (Figure 3.3).
Interviews were conducted with teachers. A total of two sets of interviews were conducted. Each teacher interview lasted approximately 40 minutes, and the interview was video recorded and transcribed for future analysis. The first set of interviews explored teachers’ beliefs about active learning and approaches to teacher professional development. The second set of interviews, which took place immediately after completing the action research project, explored beliefs and perceptions about the benefits and limitations of the action research, the impacts on professional knowledge development, and the understandings of teachers’ changed practices with their participation in the action research group. Examples of the first set of interview questions included “What strategies would you try to help students to promote active learning?” and “What does active learning mean to you?” In the second set of interviews, example questions included “As a participant of the project, how has the project changed your beliefs about active learning?”,
“Did your involvement in the action research process help you develop professionally? Please explain.”, “Did you learn anything about your own likes, dislikes, strengths, or weaknesses as a result of engaging in action research?” (Main interview questions with teachers were listed in appendix D). To provide a physical sense of the data collected during teacher interviews, a teacher interview photograph sample is shown below (Figure 3.4).

![Teacher Interview Sample](image)

**Figure 3.4 Teacher interview sample (by L. Yu)**

**3.4 Data Analysis**

Since there were two levels of overlapping data collection (teachers and researcher), there were two levels of analysis.

**3.4.1 First level data analysis (Participating teachers’ part)**

Three participating teachers analyzed their own data (students’ pre- and post- tests data; observation and work sample data; and daily TR) and summarized their findings in the form of a
final report, which was shared in the last research team meeting. Teachers did not rely only on reflection and intuition to analyze data but also through several strategies. The following MacLean and Mohr (1999) strategies were introduced to help teachers navigate data.

- **Categorize and sort.** Sorting data into categories to identify potential themes is an effective way to organize findings (Anderson, 2009). In this study, teacher-researchers recorded key quotes and observation details on index cards and sorted them into categories to help understand “what’s going on?” in the classroom.

- **Order.** Data could be sorted based on its chronological order, frequency, engagement level, or importance and the sorting could facilitate data analysis (Anderson, 2009). Data are ordered in various ways in this study. For example, chronological ordering of students’ data was introduced by three teacher-researchers. It helped the teachers understand students’ development through the active learning processes.

- **Identify and acknowledge assumptions.** Action research group is an ideal platform for identifying and exploring assumptions a researcher brings to the process (Anderson, 2009). When assumptions were unacknowledged, teacher-researchers would only see what they expected to see. For example, an unacknowledged assumption that Lee held prior to the study was that students would achieve higher achievement when they worked individually. He stated that such an assumption prior to this action research project had led him to ignore findings that interactive strategies are effective for students.

- **Talk with students and others about what they think.** In this study, this strategy was
widely employed by teachers to know what students are thinking toward the research lessons. They claimed talking with students is a useful way to understand what is going on in the classroom. Moreover, they thought it was also an important way to check the effectiveness of introduced strategies and help the students become active learners. According to my observations, the teachers always talked with students after class.

3.4.2 Second level data analysis (My part)

The researcher analyzed each data source, including classroom observations, interviews, and research team meetings, on the second level of analysis (Bruce et al., 2011).

- Classroom observations

Building on planned research, observations help decipher not only what people say, but also what they do (Gillham, 2008). Observations provide insights into what is happening in classrooms, and provide additional information about classroom teaching and learning. Observations by the critical friend and me were used in this research to increase the reliability of observational evidence (Yin, 2008). Moreover, direct observation and participant observation were both utilized to gain in-depth understanding, while providing both inside and outside perspectives (Yin, 2008). It should be noted that most of the research lessons had students working in collaborative small groups. Therefore, when acting as a participant observer, the critical friend and I would take part in the group work. The students in the group asked questions and discussed problems with us.

Field notes were collected in each observation to capture events, actions, contexts and
reflections as they happened in the classroom (MacNaughton & Hughes, 2008). These observations focused on assessing how successfully research lessons had exposed students to active learning and how effectively teachers promoted its use in the classroom (Hart & Carriere, 2011). Drawing upon data collected through observations, *thick descriptions* (Ponterotto, 2006) were analyzed for recurrent themes and patterns. Patterns of interactions, engagement levels and observations of students’ active involvement in the learning process over time were tracked. Moreover, teachers’ roles and their attempts to create active learning opportunities for students, the activities and strategies they introduced in the classroom, and changes that occurred in the classroom were identified during the observation.

● **Research team meetings**

In order to identify and evaluate teachers’ changes in different phases of the action research cycle, 18 research team meetings were videotaped to track group and individual changes. Analysis of the research team meetings began with coding the teachers’ development, the factors contributing to the development and the challenges and struggles experienced through the study (Fernandez & Zilliox, 2011). The tapes were studied closely and viewed multiple times in order to accurately identify themes and categories (Tepylo, 2008).

Initially, pre-existing categories drawn from the literature review were applied. These categories included: changes in participating teachers’ roles; knowledge and beliefs of active learning; role of active learning strategies; and attitudes toward difficulties. However, these categories evolved as new themes were identified (such as the relationship between active
As new categories emerged, coding parameters were expanded and adapted (Tepylo, 2008). Once data collection was finished, each category was examined and refined. I used three techniques in the data refining process, including pattern-matching, explanation building, and crosschecking with the research questions. In order to overcome potential obstacles to the validity and explanation of the findings, I focused on significant aspects (such as what strategies the teachers introduced to create active learning opportunities) and rival explanations during the data refining process. Moreover, other research team members were also welcomed in the analysis phase so as to provide feedback on the generated themes and categories.

- **Interviews**

  Both sets of teacher interviews aimed to provide deep insights into participating teachers’ responses by examining their experiences in participating in the action research group. The interview questions were translated into Chinese and interviews were conducted in Chinese. The interview conversations were recorded and re-listened to multiple times to ensure the transcripts were accurate. Each piece of data was reviewed and analyzed several times to locate patterns and themes accurately. The coding process incorporated several steps. The first step was the basic coding to identify concepts. Text units (sentences and paragraphs) were sorted into categories (e.g., attitudes toward active learning, challenges and success of promoting active learning, and active learning approaches tried). The second step was to make constant comparison across the datasets (Rubin & Rubin, 2011). Themes derived from the research questions and the literature (e.g., active learning, professional practice, collaboration, and curriculum reform) were used to
identify subthemes (e.g., lack of confidence, relational understanding, collaborative inquiry and reflection, use of active learning principles to guide teaching, etc.).

3.5 My role in the study

As mentioned above, my role in the study was multi-faceted, including facilitator, supporter, participant, researcher, and teacher (Goodnough, 2011). As a facilitator, I needed to firstly help teachers understand the purpose and objectives of the study, the reasons to adapt teaching approaches, and the importance of active learning. Secondly, I helped participating teachers to understand how they would get involved in the study, what types of data would be collected, and how to analyze the collected data. Thirdly, during the research team meetings, I needed to facilitate discussions, organize and record meetings.

As a supporter, I reassured that our work was on track, and provided supporting materials related to the research and potential active learning strategies to the team during the study. Although I was engaged in the action research with the teacher participants, I, as a researcher, also assumed a more traditional role in disseminating research outcomes about teacher learning in academic and practitioner journals (Goodnough, 2011).

As a former teacher who taught Grade 10-12 mathematics in China, I was familiar with the challenges teachers have to face in promoting active learning. In this case, I could anticipate the frustrations teachers might experience when creating active learning opportunities for their students. Moreover, my former teaching experiences enabled me to collaborate with participating teachers in a more comfortable way. Under such circumstances, it would be easier for me to help
the teachers analyze and solve the problems they faced during the research.
4 Findings

In this chapter, the results of this study are presented and discussed. Three participating teachers’ experiences are described. Each of the three participating teachers’ professional development is also investigated.

4.1 Introduction

In reporting these findings, the experiences of the three participating teachers are documented and analyzed. Findings are organized into groups that correspond to the overarching research question: “How do high school mathematics teachers in China create active learning opportunities for their students?” The descriptions are also guided by the guiding questions (outlined in section 1.2):

1. What approaches have teachers tried and what challenges and successes do teachers report prior to the study?

2. What strategies do teachers try while participating in an action research group?

3. How are teachers' understandings of their practice changed with their participation in the action research group?

These questions focus on understanding “what went on in the classrooms?” when teachers tried to promote active learning in conjunction with their participation in the action research group. Strategies such as introducing activity into the class, small group cooperative learning and peer teaching were widely employed in three participating teachers’ classrooms. However, due to
the variation in students’ academic achievement level in each teacher’s class, the ways these strategies were introduced and the methods used to overcome the challenges varied among teachers.

As discussed in the previous chapter, this study enabled teachers to work together to plan what instructional practices and techniques to implement, what changes to make and how to improve their instruction. Therefore, teachers’ dynamic attitudes and beliefs toward their teaching and their practices were also presented in the study.

4.2 Professional practice

Based on the data collected from research team group meetings, along with the dynamic pattern of interaction between teachers and I during the eighteen group meetings, several aspects of teachers’ professional practice changed with participation in the action research group. It was evident that teachers were gaining specific knowledge of what went on in their classrooms based on their systematic data collection and analysis. The meetings in the first phase (Participating in the active learning workshops) were mainly in the question and answer format. For example, in the second research team meeting (What is active learning? What is action research?), I posed eight questions to find out information about what were teachers’ concerns about active learning and action research, how they would conduct their research, and so on. The teachers answered these questions by giving in-depth descriptions of their thoughts. The pattern of interaction was therefore my questioning and teachers’ answering.

Unlike the meetings in the first phase, teachers led the meetings in the second phase
(Creating active learning opportunities). For example, the research team worked together to craft each teacher’s strategic plan in the first research lesson. The approaches and ideas that the teachers adopted were relatively new. In the 8th research team meeting, teachers raised issues, discussed perceived challenges, provided solutions, strategies and proposals for their concerns, and shared ideas and knowledge with the team. For example, Lee shared the success of peer teaching with the team. The teachers also discussed the challenge they encountered when students felt awkward toward new teaching approaches. New potential steps to solve the problem were also provided through teachers’ cooperation.

In order to improve teaching practices and create active learning opportunities for their students, the teachers spent a lot of time in data collecting, strategic plan designing, and practice evaluation. When teachers gained confidence and had evidence in the development of their teaching practice through data collection, they described the development, success, and strategies to overcome challenges with the team. As the core concepts of this study, “how do teachers create active learning opportunities for their students” and “how teachers’ professional practice changed with participation in the action research group” will be discussed and presented in detail in the following sections.

4.3 Lee’s experience of the action research

Lee is the most experienced teacher participating in this study. He has taught math for 26 years, 19 years of which were spent teaching high school mathematics (grade 10 through 12). He is also the mathematics team leader of Renhe High School. Lee’s class-6 is comprised of 36
students, 20 boys and 16 girls. As mentioned above, class-6 is ranked as the top-level class among nine Grade 10 classes.

4.3.1 What had Lee tried and what challenges and successes did Lee report before participating in the action research?

Lee thought the resistance of traditional teaching methods from students in the past 5 years was the main reason for him to participate in the action research group. The expectation for participating in the action research group was to improve his teaching practices to help students become better active learners. Lee believed that it could increase students’ motivation to learn and strengthen students’ interest in math.

Lee: …I’ve taught math in Renhe high school for 19 years. Students’ changing needs toward math learning within past five years made me deeply realize the disadvantages of traditional teaching methods (in China). In the past 5 years, students showed strong resistance to traditional teaching methods… I could clearly notice that students felt bored when I was lecturing and could not concentrate in class for long. Importantly, the passive environment greatly influenced students’ interests and enthusiasm in mathematics learning. (The first set teacher-interview excerpt)

However, Lee insisted that active learning may be inadequate to help students obtain greater academic achievement. He believed that higher academic achievement and greater productivity could only be obtained through extensive practicing and exam skill training. Likewise, Lee claimed that traditional teaching approaches would be better in guaranteeing high academic achievement than active learning. These notions are aptly reflected in the following comments by Lee:

Lee: …Apparently, traditional teaching methods are not as interesting as active learning approaches. But it can help students gain high score. With a large amount of practicing,
students’ testing skills will improve. This is really important for gaining high score. (The first set teacher-interview excerpt)

At the same time, Lee also expressed concerns about the NCR, which reflected his understandings of challenges that he had to face in promoting active learning. Lee deemed the gap between “The Standards” and daily teaching as the main challenge in promoting active learning. He also pointed that bridging the gap between theory and practice would be the best way to create active learning opportunities. Lee acknowledged that more guidance in helping teachers understand the relationship between “The Standards” and active learning was required. How to utilize “The Standards” to create active learning opportunities for his students was the main question that Lee wanted to answer by participating in the action research group.

Lee: …When the eighth NCR Standards were promulgated in 2001, teachers were really excited about it. We all thought that if we follow the standards, the existing teaching methods would be changed. The concepts, guidelines and standards of the eighth NCR were really attractive. We thought it would have the potential to help students learn math actively and happily… However, after a couple of years, we found that it was really difficult to implement the standards or incorporate the concepts into daily teaching. (The first set teacher-interview excerpt)

Interviewer: What do you mean that you found it difficult to implement the standards or incorporate the concepts into daily teaching?

Lee: I mean, although every teacher had the book of the eighth NCR, in which all the concepts, theories and standards were included, it was really difficult to transfer the words in the book into daily teaching practices. In our school, although every teacher had taken part in the professional upgrading program of the new NCR, it failed to offer any effective guidance to curriculum practice… Just like creating active learning opportunities, the in-service teacher professional upgrading programs are all about active learning’s potential and significant impact. It seldom provides practical guidance on how to create active learning opportunities…(The first set teacher-interview excerpt)

Lee noted that creating an active learning environment was important and he continued
exploring equitable teaching approaches to implement these approaches into his class. For instance, in the past three years he employed multimedia tools, such as PowerPoint presentations, in traditional lectures to improve teaching. However, Lee stated PowerPoint slides failed to engage students consistently during the learning process and more strategies to engage students should be introduced. Moreover, based on his past experiences, Lee questioned how effectively multimedia tools encouraged interaction, promoted critical thinking and helped students learn math actively. Therefore, finding the pedagogical practices and methods that can most effectively engage students in active learning became the main goal for Lee to achieve in this study. Due to a lack of required guidance of promoting active learning, Lee experienced many difficulties though he had the desire to improve his teaching in the past.

Lee: In order to incorporate the eighth NCR standards into my teaching, I employed a couple of strategies in my teaching in the past three years, such as PowerPoint slide presentations. It succeeded because I used colorful pictures and videos to attract students’ attention. However it was not able to engage students consistently. Therefore, the effectiveness of these strategies in promoting active learning or benefiting students still needs to be re-examined. What strategies would be the most suitable ones should be explored in the two-month research teaching (The first set of teacher-interview excerpt).

Based on the success and challenges he had in the past, Lee mentioned several principles he planned to incorporate into research lessons to create active learning opportunities for his students. As revealed in the interviews, these principles were also reflective of Lee’s understanding of how he tried to create active learning opportunities for his students. The principles Lee stressed most were based on his students’ situation. Moreover, Lee deemed these principles could provide guidance and sources for him to effectively plan and implement
research lessons. Principles of active learning helped him to identify the learning objectives, which should focus on helping students develop an active relationship with mathematics, instead of “covering the material”.

Lee: …After learning about active learning for a month, I have to admit that the first challenge I would face is how to integrate principles of active learning into practice. Therefore, to promote active learning, there are three principles that I would consider most in the following two months. Firstly, I think more time should be spent on lesson planning. I hope my teaching could reflect the charm of mathematics, instead of purely covering the material. I would give students more time in problem solving, discussions and cooperation, instead of repeated training… Secondly, the strategies introduced in teaching should emphasize more about improving engagement and involvement. The last principle, I think, should be to relate classroom math with students’ life experiences. The real life contexts would greatly help students in solving mathematics problems since students acquire a better understanding of math by discovering that it is already part of their lives (The first set of teacher-interview excerpt).

4.3.2 What strategies did Lee try while participating in the action research group?

As mentioned above, Lee’s class-6 is the top-level class among nine grade 10 classes in Renhe High School. There are 36 students in his class in total, with 20 boys and 16 girls. The students in class-6 sit individually in the classroom.

Interviewer: You said your strategic plan always considered the main features of class-6 students first. Can you tell me why?

Lee: The students in class-6 are different from students in class-5 and class-7. So, the strategic plan should be different. Class-6 students are really smart and they love math, but they don’t like traditional teaching methods. I refer [the traditional teaching methods as] to focus on teaching at a fast pace and covering a lot of materials, and emphasize on memorization and correct answer. These students desire to learn math in a more comfortable environment. You know, it’s more like they can control the pace of math learning … Students in this class prefer to work individually. I mean they always think they could solve the problems on their own and seldom pay attention to other students or discuss math problems with others. I think that’s the reason for low-level engagement, and this situation normally made them lack of a holistic and deep understanding of the newly learnt knowledge… Therefore, the strategic plan should focus on helping students to engage with
math learning (The second set of teacher-interview excerpt)

In order to provide a representative example of how Lee created active learning opportunities for his students, two of his lessons are highlighted below. His teaching methods and strategies on promoting active learning are discussed.

**Featured Lesson 1: Law of Sines (The first research lesson, March 3th, 40 minutes)**

As observed in this lesson, Lee employed a variety of strategies to promote active learning. He utilized a PowerPoint presentation, handy scanner, small group cooperative learning, activities and peer teaching. The following part is an excerpt of the 7th research team meeting, which demonstrates how Lee intended to create active learning opportunities for his students.

Lee: PowerPoint presentation and handy scanner are strategies I’ve witnessed successful in my class, I’ll adopt these two for sure. I think cooperative learning would be an appropriate strategy to engage students. When they feel bored to prove the law, it would be a wonderful thing to find someone to discuss with. About grouping, I want to copy the way shown in the Japanese video, the TIMSS (The Trends in International Mathematics and Science Study).

Hen: So you mean to encourage the students to stand up and discuss the problems with anyone they want? Why? Aren’t you afraid that the class would be out of control?

Lee: Why do you want to control the class? Based on the principles of active learning, I think we should let the students control the class. Let students form their groups freely would be easier for them to use cooperative learning. You know, in the past they always preferred to work alone. Cooperative learning is new to them.

Sue: Yes, Division based on students’ choices may be more suitable for students in class 6.

Lee: I think we should encourage the students to communicate with others first.

The changes Lee wanted to create were based on the idea of promoting active learning through cooperative learning. With the guidance of active learning principles, Lee thought active learning should be student centered and therefore students need to have the opportunity to control their own learning. In terms of cooperative learning, he thought it should be a suitable
way to involve more students in the learning process and could actively engage students consistently.

This lesson focused on demonstrating and understanding the “Law of Sines”. The introduction did not rely heavily on prescribed materials. Instead, it included activities to help students understand the meaning, potential and limitations of the concept.

**Activities.** Lee started the lesson by reviewing the knowledge related to a triangle’s sides and angles. According to the observation, only a small number of students participated in the activity, while the majority watched Lee silently. After three minutes, Lee began an activity called “guess and prove” using PowerPoint slides to present the concept “the larger angle of a triangle is opposite the longer side and the smaller angle of a triangle is opposite the smaller side.” In order to actively engage students and encourage them to develop their individual understanding, Lee provided students with four possible equations that might correctly reflect the concept. Then he asked them to determine which one or ones might be correct and then prove it.

The four possible equations are:

1) \[ \frac{a}{A} = \frac{b}{B} = \frac{c}{C} \]

2) \[ \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \]

3) \[ \frac{a}{\cos A} = \frac{b}{\cos B} = \frac{c}{\cos C} \]

4) \[ \frac{a}{\tan A} = \frac{b}{\tan B} = \frac{c}{\tan C} \]

In the first few minutes, students worked on the problem independently. During the time when students worked on the task, Lee circulated among them. It allowed Lee to interact with his
students and conduct a quick assessment to determine whether the activity was challenging or complex enough to require group work. The students easily determined which equation was correct, but they had difficulty in proving it. Therefore, Lee asked the students to discuss how to prove the equation in small groups of their own choices. Then they stood up and moved around the classroom to discuss the problem with others. Some of the groups were made up of two students, while other groups consisted of four to five students.

**Challenges emerged during the small group cooperative learning section.** The most significant challenge that emerged during this section was the apparent uneasiness students felt toward cooperative learning. In fact, many of Lee’s students had never worked cooperatively in class. Since they lacked the necessary skills to collaborate effectively, the students silently sat side-by-side at the same desk and solved the problem individually as they did in the past. Some students waited for other group members to finish the problem and got the answer from them. Faced with these challenges, Lee encouraged students to share their thoughts, discuss materials and help others in the group. However, the encouragement failed to change the situation. Some students questioned the purpose of group work. As a participant observer, I asked the students why they did not want to take part in the group work. Some students replied, “I don’t know how to discuss, it’s kind of like sharing my solutions with others. It’s really embarrassing if my answer is not correct”. Some of the students told me the group work is merely a waste of time. A high academic achieving student said, “if I can find the correct answer by myself, why should I waste time to share my answer with others?”. Apparently students did not see the value and
potential of small group cooperative learning. Therefore, helping students recognize the value and effectiveness of small group cooperative learning became the first thing Lee had to consider.

**Challenges emerged during the peer teaching section.** The subsequent section was peer teaching, during which students were encouraged to be peer teachers and present their group solutions in front of the class. The volunteers were randomly selected and different group solutions were compared by students. The handy scanner was introduced to present students’ solutions quickly on the electronic white board in this section. Unlike in the small group cooperative learning section, students were highly motivated in the peer teaching section. Students engaged in inquiring peer teacher, exploring ideas and concepts and checking if the peer teacher’s solution was the best. For example, they asked the peer teacher questions such as, “Have you checked the third equation?”, “Can you prove that? I mean not use special triangles to find the correct one?”, “Do you think my solution is better?”. However, due to lack of required peer teaching skills, peer teachers all appeared uncomfortable when they were presenting the solutions. They were extremely nervous when answering students’ impromptu questions in their own words. Some of them kept asking for help from Lee and many hoped Lee could answer peer learners’ questions instead. Lee refused to offer help and encouraged other group members to help the presenter.

Although the peer teaching section was not smoothly carried out, the learning environment changed and interaction between students increased. Students were actively involved in the learning process and they became more willing to interact with Lee in the subsequent “solutions
reviewing” section.

**Practicing and summarizing.** The lesson ended with practicing and summarizing. The intention of practicing was to strengthen students’ understanding of the lesson and help them realize the potential of the “Law of Sines” as well as its limitations. The summarizing part was designed to help students understand the importance of the “Law of Sines” and reveal the problems that students overlooked in the small group cooperative learning and peer teaching activities. However, in order to fully cover the concept, this part was mainly lead by Lee. Students were asked to take notes.

**Featured Lesson 2: Finding the general term of a recursive sequence (April 15th, 40 minutes)**

The lesson, “Finding the general term of a recursive sequence,” was a typical example of how Lee faced and overcame challenges and how he created active learning opportunities for his students. In this lesson, PowerPoint presentations, handy scanner, problem solving activities, exploring activities, small group cooperative learning and peer teaching were introduced.

This lesson was implemented six weeks after the first research lesson. Prior to this lesson, students mastered the knowledge of two basic sequences, arithmetic sequences and geometric sequences. “Finding the general term of a recursive sequence” was a lesson that Lee designed to deepen and enrich students’ cognitive reasoning of sequences. It also aimed to help students review and explore the knowledge related to arithmetic sequences and geometric sequences.
Additional strategies. In the 8th research team meeting, the group discussed and analyzed how essential interpersonal and small group skills are in successful cooperative learning. These skills enable students to take part in the cooperative learning effectively and therefore they are especially important for the long-term success of learning groups. Lee stated, “Based on the data collected in the research lesson ‘Law of Sines’, I think we overlooked the importance of those skills. In addition, we must make sure students understand the benefits of cooperative learning. I think these are key elements of effective group work.” (the 8th research team meeting excerpt, see table 3.2 in chapter 3). Therefore, after the first research lesson, Lee made time to teach students the value of cooperative learning skills (e.g., listening, sharing, critiquing, compromising, and contributing ideas). Required peer-teaching skills were also shared after the first research lesson, to ensure the students understand that peer teaching is used to help both peer teachers and peer learners develop stronger skills during the learning process (the 9th research team meeting excerpt).

Based on the data Lee collected during first month’s research lessons, Lee found that “When grouping was based on students’ choices, students always end up working together with friends or with the same people” (the 12th research team meeting excerpt). In order to change the situation and give students more chances to meet and work with other peers, Lee decided to encourage students to change group composition and increase diversity within groups (the 12th research team excerpt). Lee claimed, “I think richness of ideas and perspectives, as well as the shared learning are significant aspects that could benefit every student in a group. Apparently,
working with the same people could not achieve this goal” (the 12th research team meeting excerpt). This is also deemed as the main reason he wanted to improve the grouping method.

The lesson “Finding the general term of a recursive sequence” implementation. Lee began the lesson by posing a problem and encouraged students to solve the problem in different ways. During the first few minutes, students worked on the problem individually.

The problem:

If sequence \( \{a_n\} \) and \( \{b_n\} \) are defined by: \( a_1 = 1 \), \( a_{n+1} = 3a_n + 4 \), \( b_n = a_n + 2 \),

1) Find the first six terms of \( \{a_n\} \) and \( \{b_n\} \);  
2) Find the general term \( a_n \) of \( \{a_n\} \).

This activity, called “guess-and-verify,” was comprised of two stages and was designed to promote math understanding by having students to guess, practice, manipulate, reason, and solve the problem. In the first stage, students were expected to be able to observe the patterns and guess the following terms (the first question). In the second stage students should be able to integrate the clues obtained from the first question and connect concepts and skills to generalize the \( n^{th} \) term of the sequence \( \{a_n\} \) (the second question).

Again, Lee circulated among the students when they worked on the problem individually. The circulation revealed that students easily solved the first stage of the problem, but more than half had difficulty on the second one. Therefore, Lee encouraged students to exchange thinking through small group cooperative learning. Students were also allowed to get up and move around.
in the classroom to discuss the problem with different group members, but they were asked to change group composition this time. In this way, students could join different groups to share solutions with others. There were 2-5 students in each group.

Lee continued circulating and observing the students. Sometimes he intervened to assist students in completing the task accurately and working together effectively. According to the field notes, the assistance Lee offered during the circulation was mainly “asking and answering questions or helping students identify problems”. At the same time, Lee reminded students to use their collaborative skills and encouraged them to solve problems through different methods.

During this activity I noticed, “most of the students verbally explained their thinking and solutions to each other” (from this lesson’s observation field notes). “They also carefully listened to others’ methods, discussed the details with them and did not hesitate to share their thinking or offer help in the group” (from this lesson’s observation field notes). Apparently, students were engaged and involved in the group cooperative learning process. In order to engage more students in the learning process, Lee encouraged every student to contribute to the group work and offered help to those with difficulties. With Lee’s assistance, the students’ participation and student-student interaction were improved.

Unlike in the first research lesson when volunteers were randomly selected to present their group's answers, Lee carefully selected three students (one from each group) to present their group’s solutions to the class. The students had one minute to prepare their explanations with
other group members. Every student posed his or her solutions on the white board through handy scanner. Before peer teaching began, Lee reminded the students that from the moment the peer teacher stood in front of the class, Lee was not the teacher anymore. Every peer teacher should make sure that he/she was not explaining the solution to Lee, but to the whole class. Lee stated, “peer teachers should express their thinking explicitly during the teaching and help other students to clarify their thinking toward the solution”.

This time, the peer teachers were very confident when they exchanged ideas with other students. Most of them could articulate their thoughts and provide evidence to support it. More importantly, some peer-teachers helped other students notice their mistakes and find out the solutions. For example, the peer teacher Xia helped one student find out his mistake when looking for the general term of \( \{a_n\} \). She asked the student, “Can you tell me why you think \( \{a_n\} \) is an arithmetic sequence?”, “So you find out this is not an arithmetic sequence, then what is the difference?”. Through these questions, the student noticed his mistake and improved his understanding of sequences.

Other students seemed more comfortable and open this time when exchanging ideas with a peer. “Students carefully listened to peer teacher’s solutions and posed questions to reveal and correct the errors when necessary” (from this lesson’s observation field notes). Sufficient time was given to students’ critiquing and discussion. Surprisingly, after the peer teaching, students requested to be reviewers of these three typical solutions. They compared the solutions and expressed their thinking toward it. What Lee did was to help and monitor the review, check and
reinforce correct solutions. As the principal commented during the observation: ‘I found that using this approach (peer teaching) was very worthwhile. Almost all the students were engaged in the peer teaching process and they were not afraid to ask questions. That’s a good sign for achieving high engagement.” Similarly, Lee echoed these comments in the 13th research team group meeting, “The students loved the approach. They were highly motivated, and they really understood their peer teachers’ ideas. It keeps me interested and motivated to try peer teaching in the future.”

After reviewing the methods, Lee posed another problem. This problem was an extension of the first problem and the strategies Lee employed in the teaching and learning process were similar.

4.3.3 How did Lee’s understanding of his practice change while participating in the action research group?

Based on the data collected from the second set of teacher-interview with Lee, his participation in the study allowed him to promote active learning effectively in his classroom. The experiences allowed him to rethink and refine his pedagogical beliefs. Lee’s understanding of his teaching practice was changed in the following ways:

(1) The application of active learning principles provided during the workshops in the first phase served as a scaffold across the entire curriculum. And the active learning strategies were regarded as a source of teachers’ lesson design. Lee stated that the teaching methods he employed in the past were teacher lecturing and students listening. After he
incorporated listening, looking, doing and interaction into the daily teaching routine, he commented: “Based on the data I collected from observation, student interview, students’ work sample, and daily TR, I concluded that students’ learning efficiency was improved and enhanced” (The second set of teacher interview excerpt). Moreover, Lee commented, “When students are immersed in an active learning curriculum, they could acquire deeper understanding”.

(2) Lee acknowledged the core of teaching was no longer examination skills training, but knowledge exploration and construction. In the past, Lee pointed out he would normally spend one-third of class time on new knowledge exploration and the rest on practicing and examination skill training. The emphasis on routinized practicing intends to make sure that students memorize the new knowledge and are capable of solving different problems. However, Lee found that this process could only engage students half of the time in a lecture. Moreover, due to limited opportunities for students to explore the knowledge on their own, the retention level remained low. Based on his past five years experience of mathematics teaching, Lee gradually realized repeated practicing was insufficient to help students achieve relational understanding of newly acquired knowledge and their capability of problem solving was limited.

During the participation in the action research group, Lee stated about 75% of class time was used to knowledge exploration and less than 25% of time was for practice. Through these changes, Lee realized it was easier for him to increase engagement and help
students improve retention, strengthen relational understanding, and develop thinking skills. Therefore, Lee discredited his past pedagogical belief that repeated practice was the most suitable way to guarantee higher achievement and greater productivity. According to the results of the post-research test, Lee agreed that the new teaching practices were more beneficial for students.

(3) Meeting on a regular basis to develop and share active learning strategies enabled Lee to reexamine his classroom instructions, revise current practices and obtain new strategies to address students’ needs. Moreover, the cooperation among participating teachers was operated in an interactive cycle of development. After applying what teachers obtained in the research team group meetings to the classroom, they observed the processes, detected the effectiveness and then shared the information in the next meeting. This repeated cooperation cycle also provided opportunities for Lee to continuously develop his ideas and practice.

4.4 Sue’s experience of the action research

Sue has taught math for 19 years and she spent 13 years teaching high school mathematics (Grade 10 to 12). Sue’s class-5 is one of three second-level classes in Grade 10. The class contained 45 students, with 30 girls and 15 boys.

4.4.1 What had Sue tried and what challenges and successes did Sue report before participating in the action research?

According to Sue, helping students develop active relationship with mathematics and
become active learners were the main expectations she had for participating in the action research group. After analyzing Renhe High School’s educational environment, Sue realized that if she didn’t adjust her teaching approaches to promote active learning, her students would continue to stray away from math. According to the data she collected, most of students in class 5 were passive learners. Hence, Sue hoped to transform students from rote memorization to relational understanding in learning math. She believed that actively engaging students in the learning process could help students connect with mathematics. The following excerpt reflects her feelings toward active learning.

Sue: … In 2007, the Wuhan school board divided high schools in Qingshan district into different levels and Renhe High School is at the second level. Since then, we noticed an obvious decline in the quality of students with time. Highly motivated learners, as seen in the past, can hardly be found today… Most of students in class 5 showed resistance toward math learning. Students’ focus was set in the wrong direction and became rooted in rote memorization rather than understanding and mastering new contents. Therefore, during the class time, they were unwilling to share their thinking in class or with other students... I really expect to make some changes in my teaching and hope the changes can help students to find the intrinsic enjoyment of math learning. (The first set of teacher interview excerpt)

Sue recognized that her teaching needed to be attuned to her students’ learning needs. Joining the action research group could help her develop a much greater appreciation for the need to change her teaching to cater to the diverse learning needs of students. These notions are aptly reflected in the following comments by Sue.

Sue: Under the current situation, as I mentioned, most of the class-5 students are passively learning math. They considered mathematics to be boring and really difficult to learn. Therefore, the main reason that I want to participate in the action research group is its potential to change the situation. I think the participation can help me to improve teaching. The changed practice could then help students become more active learners and involve more students in the learning process, which are the changes I desired most in these years. (The first set of teacher-interview excerpt)
Sue also expressed the interest for her own professional growth. She viewed her participation in the study as an opportunity to collaboratively find solutions to classroom challenges and difficulties with other teachers. Despite expectations, she deemed this a valuable experience for professional development. She also noted that the main challenges in creating active learning opportunities were rooted in the limited effectiveness of in-service teachers’ professional upgrading programs.

Sue: …With regard to those teacher-training programs we accepted these years, I don’t think they can help us develop professionally. Most of them last for only two days. It is too short for teachers to really learn something. What is more important, these programs always failed in offering guidance on action. The theories they provided were outdated and lack of in-depth analysis… Without required guidance, it made me afraid of making any changes in my teaching approaches. Reflecting and sharing data collected in the classroom with other teachers, systematically locating logical solutions, re-thinking my teaching, and eventually improving my teaching would be the other expectations Sue had for joining the action research group. (The first set of teacher-interview excerpt)

In order to help class 5 students become more active learners, Sue thought she should introduce problem-based learning and small group cooperative learning in the first research lesson. Sue analyzed her previous teaching methods and realized that her lectures were operated on a “one-size-fits-all” level and did not take into account that each student has a different pace of learning. Due to this discrepancy, some students would master the content quickly, while others might need additional time to process the information. Sue admitted that some students’ failure might be caused by this teaching approach and it might be resolved by introducing problem-based learning and small group cooperative learning into her classroom during the action research project. She felt that these strategies would positively influence students by
involving students at all academic levels in the learning process and help narrow the learning gap between strong and weak students.

Sue: In fact, I wanted to consider the weaker students’ needs during the lecture. But considering that it would cost too much class time to help them understand the contents, I always choose to focus on the stronger students. And according to my past experiences, the weaker students are afraid to ask or answer questions in class, and they are usually unwilling to share their thinking with others… I think this is the reason I will introduce small group cooperative learning in the research lessons. I hope cooperative learning can help to increase students’ participation. By fostering an active, interactive atmosphere among students, it would help students to be interested and attentive in the learning process. Importantly, I think cooperative learning will give weaker students the confidence to attempt challenging problems without fear of failure. (The first set of teacher-interview excerpt)

According to her past teaching experiences, Sue stated problem-based learning could increase engagement. She concluded that problem-based learning could offer challenges, motivations and enjoyable learning experiences to students. To promoting active learning, Sue commented that when problem-based learning was combined with small group cooperative learning, more students would be engaged in the learning process. In a small group, students would first try to formulate the answers on their own after a problem is posed, and then they would be encouraged to convince their peers with the correctness of their answers. Students’ solutions can be demonstrated and used to persuade others by showing the logic of their arguments. For students who had difficulties in solving the problem, they could learn by talking, explaining and listening to others. Through these processes, those students would understand math concepts more efficiently. Moreover, students from different academic levels would be involved in the learning process.

Sue: … Small group cooperative learning would enable the students to understand the
problem in different ways and eventually gain a holistic understanding of the knowledge. (The first set of teacher-interview excerpt)

Sue also raised several concerns about research lesson implementation, which reflected her understanding toward it. She noted that most of the students in class 5 never worked cooperatively in class. She needed to consider what strategies would be most effective in supporting successful group work.

4.4.2 What strategies did Sue try while participating in the action research group?

As mentioned above, Sue’s class 5 is a second-level class in grade 10. There are 45 students in the class and they sit in pairs in the classroom. Importantly, Sue stated most of the students seldom exchanged ideas with her or other students. The following lessons served as representative examples of Sue’s teaching in her attempt to create active learning opportunities for her students.

**Featured Lesson 1: Law of Sines (The first research lesson, March 6th, 40 minutes)**

Similar to Lee’s first research lesson, Sue’s first lesson also focused on demonstrating and understanding the “Law of Sines.” Besides developing students’ understanding of the concept, this lesson intended to help students realize the law’s importance as well as its limitations.

**Preparation.** Based on Lee’s experiences and solutions generated in the 8th research team group meeting, Sue employed additional strategies to make her teaching flow smoothly. First, she informed students of the value of cooperative learning before this lesson. She also stressed that cooperative learning benefited individuals, but this value can only be revealed when the
group work functioned well.

Considering the diversified learning abilities of class-5 students, heterogeneous grouping was introduced and 45 students were divided into nine groups. Every group was designed to include at least one high achieving student, two average level students and one or two low achieving students. Sue believed the grouping methods need to be attuned to her students’ learning needs and class-6’s grouping method does not fit class-5’s situation. Sue commented that placing a high achieving student in each group can help weaker students to get involved. Moreover the richness of ideas and perspectives generated by heterogeneous group work allowed students to learn from each other’s strengths and weaknesses. These notions are aptly reflected in the following comments by Sue:

If I introduce Lee’s grouping method in class 5, higher achievers would sit together and leave the lower achievers sitting together. In this situation it would be more difficult to involve the weaker students during the learning process (the 8th research team meeting excerpt).

Activities. As observed in this lesson, Sue employed a variety of strategies to promote active learning. She introduced PowerPoint presentation, small group cooperative learning, activities and peer teaching. When the class began, students rearranged their desks and sat around a small table (four desks were pushed together) with their group members. Similar to Lee’s first research lesson, Sue also started the lesson by reviewing the knowledge related to a triangle’s sides and angles. The review helped the students recall the concept “the larger the angle, the longer the side opposite the angle”. However, based on my observation, only a few students took part in the activity. Most of them were reading the textbook and sat silently. Sue
employed “The Geometer’s Sketchpad” and drew a triangle on it. She dragged the vertices to change the shape of the triangle and asked the students to answer the question, “How does the size of the angle relate to the length of the side opposite the angle?” This time, I noticed that more students became involved in the activity, though many still seemed afraid to answer the question.

The next activity introduced was “guess and prove”. Based on the concept “the larger the angle, the longer the side opposite the angle”, Sue posted four possible equations that might correctly reflect it. Then she asked the students to determine which one or ones might be correct and then prove it. The four possible equations are:

1) \[
\frac{a}{A} = \frac{b}{B} = \frac{c}{C}
\]

2) \[
\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}
\]

3) \[
\frac{a}{\cos A} = \frac{b}{\cos B} = \frac{c}{\cos C}
\]

4) \[
\frac{a}{\tan A} = \frac{b}{\tan B} = \frac{c}{\tan C}
\]

Students were then asked to work on the problem independently and at the same time Sue circulated among the groups and answered questions. However, as Sue highlighted, her students preferred memorizing new content rather than exploring it. Therefore, after Sue posted the problem, instead of thinking about the problem thoroughly, more than half of the students went directly to the textbook to find the solutions. Noticing this situation, Sue encouraged these students to close the textbook and try to find the solutions on their own. More time was given to make sure most of the students attempted the problem.
Challenges emerged in the small group cooperative learning section. Based on the information gathered from her circulation, Sue asked the students to explain orally to other group members how they solved the problem or how they got stuck. The high achieving students in each group were asked to explain the nature of the concepts and strategies they used to solve the problem, while also helping, encouraging, and supporting other students to learn. Although additional strategies were employed to help facilitate the cooperative learning, most of the groups experienced difficulty during this cooperative learning process. In the group discussion, many high achieving students seemed reluctant to help other members. With regard to other students, the average students became excluded from group interaction since high achieving students spent most of the time to teach low achieving students. Noninvolvement occurred in various groups and students began talking about everything but the group task. Sue seemed very anxious when she found that most of the students were not engaged or involved in the cooperative learning.

Challenges emerged in the peer teaching section. During the next section comprised of peer teaching, students were encouraged to volunteer their group solutions in front of the class. However, different from the situation in class-6, no student volunteered this time. Therefore, Sue had to appoint two students to be the peer teachers. Due to lack of experiences of peer teaching, both peer teachers were nervous when they stood in front of the class. They wrote down their solutions on the white board and failed to express their thinking and solution clearly to others. Moreover, the peer teachers all seemed terrified to speak to the whole class. They were even
afraid to look at other students and instead chose to look at Sue when they presented their solutions. Based on the data collected from observation, Sue claimed these students were eager to get positive feedback but at the same time they were also afraid to make mistakes in front of the class (the 8th research team meeting excerpt).

It is worth noting that, as I observed in the class, the main challenge of this part was not from the students, but from Sue. She seemed afraid to delegate authority to students. “After the peer teachers finished presenting their solutions, Sue repeated their strategies and offered extra explanations to ‘help’ other students understand the key points” (This lesson’s field notes excerpt). Under Sue’s intervention, this section was basically dominated by her. Peer learners sat silently without interacting or exchanging ideas with the peer teacher or Sue. When we discussed this issue in the 8th research team meeting, Sue stated she lacked confidence on her students and assumed that they did not know how to clearly and correctly present their solutions. This might be the main reason for low engagement of the peer teaching section.

**Summarizing.** The end of the lesson was summarizing. This section was designed to help students further develop their understanding of “Law of Sines.” The significances, potentials and limitations of the law were included in this part. However, similar challenges emerged when this section became dominated and lead by Sue again and the passive atmosphere continued.

**Featured Lesson 2: Inequality Word Problems (April 29th, 40 minutes)**

**Additional strategies.** This lesson was implemented two months after Sue’s first research
lesson. The strategic action plan was designed during the 14th research team meeting. During these two months, based on the data collected and solutions generated, Sue attempted several additional strategies to help students develop an active relationship with math and to overcome the obstacles with suggestions from eight research team meetings.

In order to successfully implement small group cooperative learning in class 5, additional strategies were employed and the effectiveness of these strategies was verified during the two-month period. The additional strategies include: First, in addition to the required skills Sue stressed before the research lesson, she also shared some videos (The 17th “Young teacher teaching competition- Hubei” video) that featured successful small group cooperative learning with students. The videos were used to help the students understand what they can contribute to the team, how to contribute and how to interact with other members. Second, to combat high achieving students reluctance to help other students and students being afraid to volunteer their solutions, Sue assigned roles to the team members. She assigned the high academic achiever as the group leader to take the responsibility of group function. Sue also helped high achievers understand cooperative learning as an opportunity to examine mathematics content in-depth. Third, every group member was given a number (from one to five) to help to carry out the cooperative learning and peer teaching. This strategy will be explained in detail below.

In the peer teaching section, a “group reward” was employed to motivate students to take part in the peer teaching process. Since every peer teacher is the representative of each group, Sue stressed that the reward would be given to the group instead of the individual. Sue also
explained to the students that groups would have the opportunity to earn a reward of ‘best peer teaching’, which would be awarded by the class. Sue highlighted the skills required for successful peer teaching after the first research lesson.

**The lesson “Inequality Word Problems” implementation.** The lesson “Inequality Word Problems” is a typical example of how Sue created active learning opportunities for her students as the study period progressed. This lesson incorporated activities, small group cooperative learning and peer teaching.

In this lesson students were expected to gain understanding of how inequalities make sense in our lives and be able to translate from inequalities into mathematical symbols. Importantly, the lesson design did not rely on the textbook and instead incorporated key concepts from various published curricula.

Sue started the lesson by introducing the activity “inequalities in our lives.” In the activity, students needed to formulate a real-life word problem that was related to inequalities. Then they were expected to translate the real-life word problem into appropriate inequalities and solve those inequalities. When students were working on the task individually, Sue circulated among them and encouraged them to get involved in the cooperative learning. After she found most of the students had formulated their own problems, she asked them to share their problems with the group. After each group discussed all the problems in detail, they needed to pick the best problem to present. The selection criteria was based on each group’s own decision.
According to my observation, students’ enjoyment in learning increased during the cooperative learning process and almost all the students got involved in the group discussion. I could see a lot of happy faces during the observation and students would applaud when they found interesting problems. I also noticed some low achieving students were actively involved in group discussions. Some groups even chose to formulate a new problem together for the presentation. As high academic achieving students were assigned as group leaders, they became more willing to interact with other group members and help low achieving students. Some of them kept trying and encouraging silent group members to take part in the discussion. Sue stated, “I think I involved almost all the students in the learning process. For those lower level students, their attentions were focused on math learning instead of on their cell phones, the trees outside, or something else.” (The 15th research team meeting excerpt). Since this activity enabled all the students to contribute during the cooperative learning process, the interaction between students was developed and improved.

Instead of calling on volunteers to present their group’s problem, the strategy “numbered heads together” was introduced. In the numbered heads together approach, students were placed in groups and each student was given a number (e.g., number 1 to 5, for class-5 students). During the cooperative learning process, students worked together to collaboratively solve the problem. After the cooperative learning section, the teacher randomly called a specific number, and the corresponding person became the spokesperson for the group or peer teacher.

The following part is an excerpt of the 10th research team group meeting, which served to
explain why and how the strategy “numbered heads together” is introduced.

Sue: I’ve introduced peer teaching to promote active learning for two weeks, but the situation was not improved during that time. Even though I employed additional strategies, such as informing other teachers about required skills, assigning roles to the team members, the outcome was still disappointing. The volunteers were always group leaders (the high academic achiever). I once tried to ask some lower achieving students to present their group’s solution, and guess what, one girl cried when I asked her to be the peer teacher.

Lee: There are too many girls in your class. Girls tend to be more afraid of making mistakes in front of the class. It is also possible that they want to present, but pretend they don’t. Why don’t you try the name cards? I mean, you can randomly pick a student from students’ name cards. Or you can number the entire class and randomly choose a number. Apparently, the key factor of cooperative learning is to get students involved.

Hen: But it is possible that all the peer teachers are from one or two groups. We have to figure out a way to involve those passive lower level students.

Sue: Or I can number the students in every group, from 1 to 5. I just need to randomly choose a group first and then choose a number. Therefore, all team members must be prepared to present, because no one knows which number will be called. And I do not need to worry that all the peer teachers are from one group... In this case, lower achieving students could be involved in the peer teaching process without fear or embarrassment to be the peer teacher. This strategy can also give lower level students confidence because they know they will have the correct answer to give to the class.

According to Sue, involvement would be an important factor which influences active learning. Numbered heads together is an effective cooperative learning strategy that facilitates interdependence, while promoting individual accountability. More importantly, it could help involve students at different levels in the learning process.

In this lesson’s peer teaching section, the number five students were called to be the peer teacher. They were asked to pose their group’s problem in front of the class and could randomly choose a group to solve the provided problem. After every group’s problem was shared, the best would be selected and rewarded (the ‘best peer teaching’). Students were fully motivated and
they carefully read other group’s problems and try to find the best solution. They were also engaged in exchanging their ideas, perspectives, difficulties and questions with the peer teacher. For the students who were chosen to solve the peer teacher’s problem, Sue kept encouraging them. When students had difficulties to solve peer teacher’s problem individually, Sue noted they could ask for help from other group members. The learning environment was quite different from the first research lesson. Students were actively engaged in the learning process. Moreover, during the review, the process was not led by Sue anymore, but the students.

To conclude the lesson, Sue posed several word problems about inequalities on the white board. According to the TR provided by Sue, most of the students could get the right answer and they were no longer feared in presenting their solutions to Sue. Based on the data collected from this lesson, Sue was convinced that the additional strategies employed had a positive impact toward creating active learning opportunities.

4.4.3 How did Sue’s understanding of her practice change with participation in the action research group?

According to the data collected from the second set of teacher-interviews and during each of the 18 research team meetings, Sue changed her pedagogy and beliefs toward active learning in the following ways:

(1) Since this study provided opportunities for Sue to collaboratively learn from her own experiences and make this experience accessible to other participating teachers, the
effectiveness of her teaching increased. Coupled with sharing her research lesson experiences, findings and practices, it allowed Sue to find solutions to classroom challenges, while also promoting her professional growth. As illustrated and discussed in the above section (section 4.3.2), this study encouraged Sue to examine the dynamics of her classroom, ponder the employed strategies that intend to promote active learning, validate and challenge existing approaches, and employ additional strategies to improve the teaching. Sue’s experiences have illustrated that if more teachers can develop academically and grow professionally, more students can benefit from active learning in the classroom (Hewitt & Little, 2005).

(2) Based on the data that Sue collected from the pre-lesson test, post-lesson test and one set of post-research student interviews, Sue deemed that the changed teaching practices had positive effects in developing students’ potential and developing their active relationship with mathematics. These findings greatly influenced her pedagogical beliefs.

**Sue:** In fact, I think class-5 students all love math, but this potential had not been fully explored in the past. Moreover, according to students’ performances during the two-month reform-based teaching, I found students' potential is actually infinite. As a teacher, I think we need to capitalize on the reform-based teaching to let your students surprise you. There are a number of students in class-5, who really impressed me during the reform-based teaching. For example, Guang is the most impressive and typical one. I always thought Guang was not good at math and maybe he does not like math. In the past, he never raised his hand to answer any questions in class and always failed to finish the homework well… But according to his performance in these two months, my attitude toward Guang was totally changed. He gradually became active in the class. He raised his hands almost everyday and most of the solutions he shared with other students were extremely creative and innovative, which were also quite easy to be accepted by other students… I think the active learning strategies really helped him to build confidence in mathematics learning… Students’ changes made me rethink my own teaching. I think teachers should trust the
students at first, to believe that they do know, and can do a great deal. Then they should try to find equitable teaching approaches, such as cooperative learning and peer teaching, to fully develop students’ potential. (The second set of teacher interview excerpt)

(3) The principles of active learning provided in the active learning workshops gave Sue opportunities to gain a clear understanding of how to introduce new concepts. It also served to help Sue design appropriate learning activities. During the action research period, Sue introduced a variety of different activities to engage and motive students in mathematics learning. Sue deemed that well designed activities, especially the introduction activity, would help the teaching process to run smoothly. Additionally, she thought it engaged students in the learning process for a longer time. These findings made her rethink the factors that constitute good teaching practices.

Sue: … A good introductory activity is a good start of a successful active learning class. Most of the time, I even thought whether students can be actively engaged in the learning process totally depends on the activity introduced during the teaching… Therefore, in the future, I would spend more time in formulating suitable activities for the lesson design, which could help increase students’ interests and meet their needs. Moreover, to design a suitable activity, teachers should consider more about their own students. Only in this way, students can easily be involved in the activity and engaged in learning. (The second set of teacher interview excerpt)

(4) In order for students to develop active relationships with math and understand the importance of mathematics as a subject, Sue noted that teaching must focus on developing a relational understanding of the knowledge rather than revolving around routine exercises. For Sue, relational understanding meant seeing how things work, how things are related to each other and why they work like they do. Routinized exercises and meaningless repetition can work for consolidating concepts, but they have little impact on generating
significant understanding. By participating in the action research group, Sue learned that “According to past tests’ results, observation, and students’ work examples, if students were given opportunities to develop relational understanding of mathematical concepts, they became active in learning meaningful mathematics content” (The second set of teacher interview excerpt).

4.5 Hen’s experience of the action research

Hen has taught secondary school mathematics for 21 years, with 17 years spent in teaching high school (Grade 10 to 12). The Grade 10 classes in Renhe High School are divided into three different levels. Hen’s class-7 is in the third-level and it comprised of 47 students. In class-7, there are 20 girls and 27 boys.

4.5.1 What had Hen tried and what challenges and successes did Hen report before participating in the action research?

Hen’s main expectations for participating in the action research group were to help class-7 students build confidence in mathematics learning and hope their confidence in math would have positive impact on improving involvement and engagement. Moreover, Hen believed that active learning strategies would be more attractive to class-7 students than the traditional teaching approaches. Hen admitted that transforming class-7 students from passive learners into active learners would be a difficult task. However, without doing so, the students would stay straying away from math learning.

Hen: …Class-7 students were treated as the “bottom-set” students in grade 10 and most of
the students think they’re not good at math. These negative feelings might stem from their memories of math learning in primary school. With weak basic math skills, most of students find the subject incredibly confusing and difficult. In class-7, about 60% students expressed no love in math. According to the results of recent tests, these 60% students normally scored below 20 (of 100). During the lecture, they just silently sat in their seats or slept. Importantly, the situation is deteriorating. The percentage of students who had negative feelings on math was increasing in the last two months. Obviously, traditional teaching approaches are losing their effectiveness for class-7 students… I think the most important thing right now is firstly helping these students to build confidence in math and eventually develop an active relationship with it… To build students’ confidence and make them become active learners, the active learning strategies would be the best choice. (The first set of teacher interview excerpt)

Based on Hen’s teaching experiences, he noticed that if mathematics teaching is resorting to rote memorization, it would lead to a superficial understanding of mathematical concepts, many of which would only remain in students’ memory for a short time. Therefore, Hen was convinced that the goal for mathematics teaching should be helping students to gain abilities that stem from relational understanding of math contents, such as the ability to connect methods, explain thinking processes and present ideas orally. He admitted active learning strategies would be helpful for retention in academic progress, gaining relational understanding, promoting positive attitude, and motivating students to become active learners.

Hen: …During my 21 years teaching, I noticed there are some students who poorly performed in Grade 12 but highly achieved in Grade 10. For these students, I found that their high academic achieving in Grade 10 was normally resorted to rote memorization. Apparently, memorizing rules help students receive accurate results. But the students are usually not able to justify their solutions through reasoning and many cannot see links between different mathematical concepts, which are important abilities in Grade 12 math learning… Some of class-7 students (about 20% of class-7) who obtained high score in time-limited tests were just memorizing the rules. Therefore, for these students, helping them to gain relational understanding of mathematics contents would be another expectation for my participation in the action research group. (The first set of teacher interview excerpt)
Hen believed that the interactions between students were fundamental in active learning. Therefore, he was committed to promote interactions between students, by introducing small group cooperative learning and peer teaching into research lessons. In class-7, the learning process was dominated by high achieving students (about 20% of class-7), while low academic achievement (about 60% of class-7) students were excluded. Consequently, Hen believed encouraging the non-participators to get involved in math learning by interacting with higher achievers would be an effective way to engage more students into math learning. Moreover, the improved interaction would provide the low academic achievers a comfortable way to learn.

Hen: … In class-7, basically there was no interaction between high achieving students and low academic achievement students… In addition, high achieving students were always more active in the learning process and participate more willingly than others… Under such circumstances, my attention mainly focused on those active students while ignoring the passive ones, who were actually the majority in the class… I think encouraging interaction between students can be a valuable method for involving every student in the class, not just some “more active” ones… Moreover, weaker students might feel more comfortable to exchange mathematical thinking with a peer than with me. (The first set of teacher interview excerpt)

With his past experiences, Hen believed that knowledge was truly mastered only when a student was able to teach it to someone else. He claimed peer teaching could help students to build confidence, increase student interaction and improve students’ communication skills. However, Hen pointed out that his teaching always focused on the minority of the class, who were the more active students, while ignoring those majority passive learners. Moreover, even though Hen was aware of the significant benefit of active learning strategies (such as peer teaching), the strategies were never introduced to class-7 students. The reason for resisting active
learning strategies lay in Hen’s lacking of confidence in the class-7 students. Hen’s participation in the action research group made Hen realized the importance of active learning and helped to increase Hen’s confidence to try peer teaching in his class.

Hen: … When I was in high school, I had a lot of opportunities to be a peer teacher. I think this experience even influenced my beliefs toward mathematics teaching. When I was (peer) teaching other students I could always gain a better and deeper understanding of the mathematical concepts and ideas. Moreover, it also had positive impacts on building confidence, increasing interaction and improving communication skills. These benefits may result in high engagement and positive attitude during the learning process… Although I realized peer teaching could benefit both peer teachers and peer learners, I never tried this strategies in class-7. I always lack confidence in the students in my class… After a month’s learning about active learning, I think it is time to introduce peer teaching to my class. (The first set of teacher interview excerpt)

4.5.2 What strategies did Hen try while participating in the action research group?

Class-7 is a third-level class in Grade 10 with 47 students who sat in pairs in the classroom. About 60% of students in class-7 expressed they disliked math and admitted to having difficulties with math learning. According to the results of various tests, class-7 students normally scored below average. The following lessons are examples of how Hen created active learning opportunities for “bottom set” students.

**Featured Lesson 1: Law of Sines (The first research lesson, March 7th, 40 minutes)**

In this lesson, small group cooperative learning, activities, activity sheets, and peer teaching were employed to promote active learning. These strategies were used to improve especially the low academic achieving students’ involvement in the learning process (the 8th research team meeting excerpt).
Heterogeneous grouping was employed and students were divided into 11 groups. Every group consisted of 4-5 students, including one high achieving student, one average student and two to three low achieving students. The high achieving student was assigned as the group leader to make sure that every voice was heard and to offer help when needed. Hen hoped by “placing students from different levels in the same group, the involvement and interaction between students would be improved” (the 8th research team meeting excerpt).

In addition, the significances and potential of peer teaching were addressed before this lesson. Hen also shared his experiences in being a peer teacher when he was at high school. Required skills and factors for effective peer teaching were mentioned.

**Activities.** Unlike Lee’s and Sue’s plan for this lesson, Hen’s lesson flow followed the design in the textbook. Right triangle trigonometry was used to develop the Law of Sines. The instructional objective was addressed and the lesson started by reviewing the knowledge related to right triangles’ sides and angles with all the students. First, Hen drew a right triangle $\triangle ABC$ ($\angle C$ is the right angle) on board and then asked the students to answer the following questions:

$$\sin A = \ldots, \quad \frac{a}{\sin A} = \ldots, \quad \sin B = \ldots, \quad \frac{b}{\sin B} = \ldots, \quad \sin C = \ldots, \quad \frac{c}{\sin C} = \ldots$$

These questions served to help students develop the relationship between $\frac{a}{\sin A}$, $\frac{b}{\sin B}$ and $\frac{c}{\sin C}$.

However, only a few students participated in the reviewing activity, while most silently sat in their seats. Noticing this, Hen began to randomly call on students to answer the questions. At this time, I found some students whispered “not me, not me” while Hen called on students. I also
noticed that, when some students were called on to answer the question, some other students would breath sighs of relief because their names were not called and said, “oh, lucky for me”. Consequently, most students were not involved. Calling on students to answer questions did not change the situation. After writing down the answers to the questions on board, the teaching moved to the next part.

After generating the formula \( \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \) in right triangle, teaching moved to the next activity. The second activity was about developing the law involving non-right triangles. Considering the students’ weak basic math skills, “Law of Sines” activity sheets (Appendix E, adapted from “NCTM: Law of Sines”, adapted with permission) were introduced. The activity sheet was designed to guide students in developing a method for solving problems that involve non-right triangles. Moreover, the activity sheet also served to help students work together in an academic setting (the 8th research team meeting excerpt). After every student received an activity sheet, Hen asked them to make the connection between the problems posed at the beginning of the class and the problems presented on the activity sheet.

When students were working on their work individually, Hen circulated among them, prepared to answer any questions, and checked if the activity was too difficult for them. Because of the guidance presented on the activity sheet, Hen noticed more than half of the students could answer the questions on the sheet. Others still had difficulties in solving the problems alone.

**Challenges emerged in the small group cooperative learning section.** Based on the information gathered during the circulation, Hen asked students to share their solutions and
difficulties with group members. Students began to move and sat around the group leader (the high achieving student). During the small group cooperative learning, Hen circulated among groups to facilitate discussions between students and answer questions. In the meantime, Hen encouraged students to support teammates and provided positive feedback to groups that all the members participated in the discussion. Although main factors for a successful cooperative learning, such as student participation, teacher encouragement, and student-student interaction (Johnson & Johnson, 1988; 1991) were achieved in this lesson, Hen also felt that the cooperative learning section still retained many difficulties and challenges (Hen’s TR of “Law of Sine”).

In the “Law of Sine” TR, Hen firstly mentioned that effective corporative learning interaction must include the following factors: orally explaining one’s solution to others, teaching strategies, checking for understanding, discussing concepts being learned, connecting present with past learning and eventually reaching a consensus for a team answer (Johnson & Johnson, 1988; 2009) (the 9th research team meeting excerpt). However, for this lesson’s cooperative learning interaction, Hen pointed out that the high achieving students dominated the discussion and did all the work. Other group members just listened to him/her and waited for the “right” answer. Importantly, for most of the groups, except of the group leader, other group members were not engaged in the learning process. They became “free riders”, who did not engage in conversation or contribute to the group, and waited for help (Hen mentioned in the 9th research team meeting).

It is worth noting that teachers’ pedagogical skills and creativity influence students’
cooperative learning to the greatest degree. In this lesson, another challenge emerged from Hen. The activity was designed to develop “Law of Sines” by making the connections between right triangle situation and non-right triangle situations. Two different non-right triangle situations were included in the activity sheet, acute triangle and obtuse triangle. According to the solutions generated from the 9th research team meeting, it would be better to divide this activity into 2 different parts, one about acute triangle (answer the question 1-13) and the other about obtuse triangle (answer the question 14). In the 9th research team meeting, Lee stated:

Dividing the activity into two parts could help to involve more students. There are two different thinking levels embedded in this activity. The first level is realizing that non-right triangles have two cases and the second level is making the connections. I have to say, for students, it is more difficult to prove the law in an obtuse triangle than in an acute triangle. So, you’d better divide the activity into two parts in class 7.

Sue also mentioned “When the activity was developed for the obtuse triangle, students could get more clues and patterns from the right triangle situation and the acute triangle situation. In this case, more students would get involved in the cooperative learning section, instead of sitting there and waiting for the ‘correct’ answers”. Apparently, teachers thought the activity was too challenging for students in class 7 and the involvement level might decrease because of that. Hence, dividing the activity into two parts could resolve the dilemma. Moreover, sufficient time should be given to allow students to complete the activity, during which groups’ results can be shared and questions can be fully discussed. Based on my observation, most groups did not finish discussing all 13 questions on the activity sheet when Hen moved to the peer teaching section.
Challenges emerged during the peer teaching section. During the peer teaching section, students were encouraged to volunteer their group solutions in front of the class. However, all the volunteers were group leaders. In fact, Hen noticed the average and low achieving students never raised their hands to ask a question during the presentation of all 14 questions. Although Hen addressed the skills and factors necessary for successful peer teaching prior to the lesson, students still had difficulty adapting to the new roles. After writing the solutions down on the white board, they all chose to present their answers while sitting on their seats instead of standing in front of the class.

Interpersonal interaction remained on a teacher-student level. Since interaction between students was scarce, Hen lead the peer teaching activity and did the work that should have been done by other peer learners, such as critiquing and discussing solutions, posing questions and correcting the peer teacher’s work. Under such circumstances, most of the peer learners were not involved in the learning process. The peer teaching section became an activity that helped students passively check their answers. Some students who sat at the back of the classroom even fell asleep during the peer teaching process.

Developing. Based on the activity sheet findings, this part intended to develop the “Law of Sines” in any triangle shape. Similar to the situation that emerged during the peer teaching activity, Hen again lead the class instead of forcing students to actively engage. Hen listed the findings from the right triangle, acute triangle and obtuse triangle and lead students to develop the “Law of Sines.” He also addressed the importance and the potential of this law as well as its
limitations. During the entire process, Hen did all the talking and students quietly sat in their seats listening to him. The passive atmosphere continued and student involvement was extremely low.

**Featured Lesson 2: Sequences (April 4th, 40 minutes)**

*Additional strategies.* This lesson was implemented one month after the first research lesson. Taking into consideration the unique characteristics and challenges of class 7, Hen attempted to incorporate several new strategies to create a more active classroom.

In order to motivate and involve more students in the learning process, more diverse activities were introduced to the lesson. Hen stated “I watched the 17th ‘Young teacher teaching competition- Hubei’ videos last week. According to those videos, I found that hands-on activities could motivate students more, such as folding paper activity” (the 11th research team group meeting expert). He also stated, “These hands-on activities made math learning more interesting for students, which in turn helped them develop active relationships with mathematics” (the 8th and 11th research team meeting excerpts). Hen called his approach “incorporating fun into math lessons.”

Hen believed in order to motivate low achieving students, he must incorporate small group cooperative learning and peer teaching (see the 7th and 9th research team meeting excerpts). To accomplish this, Hen explained that each student could contribute to a team’s success. He provided examples (The 17th “Young teacher teaching competition- Hubei” videos) showing students how to contribute and interact with others. Next, Hen employed Sue’s group dividing
strategy. He assigned specific responsibility role to each group member to make sure everyone
got involved in the cooperative learning process. Roles were chosen by students and the group leader was asked to make sure that every group member had a solid understanding of the responsibilities associated with their roles. In order to assuage students’ fears about presenting in front of the class, Hen shared his experiences of being a peer teacher when he was a student. He highlighted the challenges and difficulties he faced, as well as the enjoyment and confidence he obtained from peer teaching (the 9th research team meeting excerpt).

**The research lesson “Sequences”**. The lesson “Sequences” is a representative example of how Hen tried to create active learning opportunities for his students. In this lesson, activities, small group cooperative learning and peer teaching were employed. “Sequences” was the first lesson of the unit and the objective was to help students understand the definition, notation and special types of sequences.

Unlike in the first research lesson when students sat alone in their own seats, Hen had students sit in groups from the beginning this time. Hen started the lesson by introducing the activity “Paper Folding to the Moon.” First, a four-minute video called “How folding paper can get you to the moon?” was shown. After the video, students were expected to answer the question, “How many times will you fold a piece of paper to get you to the moon?” through group cooperative learning. The thickness of a piece of paper (10^{-3} cm) and the distance between the Earth and the moon (384000km) were presented on the white board. This activity was to help students get a geometric sequence $2^n$, and then solve the inequality $2^n \times 10^{-3} \geq 3.84 \times 10^{10}$. 

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Paper was also prepared for each group to support the activity. When students worked on the task, Hen circulated among them and encouraged students to get involved in the activity.

According to my field notes, students were “highly engaged and motivated during this activity”. Students assigned different roles to every group member. For example, in a four-member group, one was assigned to record the data, one was responsible for folding the paper, one was in charge of calculating the after-fold paper thickness, and the last person presented the findings. It was apparent that this activity successfully captivated students’ attention and positively encouraged students to become active learners. Some of the students said, “Oh, math can be this interesting” and “It’s funny”. Students’ enjoyment increased and almost all the students got involved in the group discussion.

During the peer teaching section, the situation was also quite different from the first research lesson. Many low achieving students volunteered their group’s solutions this time. In fact, a male student (Yang) who had never raised his hand in math class, volunteered to be the presenter (This lesson’s field notes excerpt). Hen noted, “Unlike the high achievers who are always afraid of making mistakes when speaking to the whole class, low achieving students normally feel more comfortable and open to be the presenter” (the 12th research team meeting excerpt). Yang appeared relaxed and natural during the peer teaching process. He folded the paper and wrote the outcomes on the board to explain how he found the pattern. Although he had some difficulties in clearly articulating how he found the final answer, his group members helped him. Students were quite engaged when the male student was presenting his solution. I noticed
almost all the students listened attentively to Yang’s solution and kept comparing his solution with their own solutions. Instead of sitting there silently, students kept exchanging ideas with Yang and his group members. Some students also volunteered to present new solutions after Yang’s presentation. With regard to Hen, positive feedback was distributed intermittently based on this group’s demonstration of encouraging and supportive behavior. The active climate continued and almost all the students enjoyed the learning process.

According to the patterns found in the first activity, Hen presented the definition, notation and special types of sequences on the white board. After students got a basic understanding of a sequence, the lesson moved to the second activity.

This second activity was called “What is the next term?” and contained three components. Paper, along with little red and white cubes were provided to each group. First, every group member had to create their own sequence using the cubes. Next, every sequence was shared within the group. When a student was sharing someone’s sequence, other group members were asked to predict the next term and explain which pattern they believed he/she was using. Lastly, each group was instructed to select the best sequence and prepare to present it to the class.

Sequences, such as 1, 2, 3, 4…, was not a new concept to students. This activity took sequencing to the next level and was designed to help students predict numbers in sequences and create new sequences. In solving these problems, students enhanced their creativity in mathematics. Moreover, Hen claimed “using their own ways to explore the problem, the
students’ general mathematical understanding was deepened” (the 12th research team meeting excerpt).

Students were highly engaged in this activity and every student was involved. After Hen circulated in the classroom, he took on the role of a student and participated in the group work. He created sequences with them and also asked them to predict the next term. Some students even said, “I’ll make a difficult one and even Mr. Hen cannot find the pattern.” According to my observation field notes, students generated many difficult and creative sequences. In the meantime, Hen offered additional instructions to students who were still struggling with the task. Reinforcement and encouragement were distributed as well for students’ efforts in working collaboratively.

The last part of this lesson involved presenting each group’s best sequence. Unlike in previous presentations, students were not afraid to speak in front of the class any more. Instead, they showed high level of confidence and hoped to get positive feedback from students and Hen. The interaction between students became fully developed. Hen monitored the activity from a distance and ensured the discussion was sufficient.

4.5.3 Hen’s understandings about his own pedagogy after the research

Hen faced many challenges while trying to incorporate active learning into the classroom. Along with the data collected from the second-set teacher interview and the 18 research team meetings, Hen’s experience illustrated his professional growth and revealed that Hen’s pedagogy
was influenced in following ways:

(1) Hen indicated that collaborative work with two other participating teachers helped him to gain a deeper understanding of how to create active learning opportunities for his students. Hen admitted that talking about his methods and learning difficulties occurred during the research lessons with the research team inspired him to reexamine his teaching practices. Moreover, working with the research team enabled Hen to enjoy teaching the new lesson. Hen was encouraged to improve his teaching in order to help students develop active relationships with mathematics. Moreover, collaboration among teachers provided an opportunity for Hen to generate additional strategies, such as grouping methods and activity design, to promote active learning.

**Hen**: Preparing a lesson, designing an activity, and forming a problem collaboratively, resulted in a different viewpoint toward teaching. It doesn’t sound like what it should be, but it was… I think collaboration is really important and I truly enjoy it. Teachers get together and talk about ideas they tried to promote active learning, share successes and difficulties they had, and then new strategies are generated. (The second set of teacher interview excerpt)

(2) By applying the principles of active learning and pedagogical approaches, Hen realized active learning was student-centered. Hen claimed “In order to create active learning opportunities for students in class 7, I should change my teaching from teacher-centered to more student-centered”. Thus, this experience deepened his pedagogical beliefs. Hen stated that moving toward more student-centered approaches forced his role to change from the traditional “imparter of knowledge” to a coach or a consultant. Students were encouraged to take the responsibility of their own learning and to get actively engaged. Under such
circumstances, Hen noted that students’ confidence, communication skills and motivation to learn improved. Moreover, in order to create an active learning environment and help more students actively engaged in the learning process, Hen developed professionally. He acknowledged that creating active learning opportunities requires a higher-level of lesson planning. This includes knowing how to effectively introduce an activity, how to attract students from the beginning and how to design most suitable activities to involve more students. Hen realized that these factors must be constantly considered during the lesson planning process.

(3) The action research approaches for analyzing practice provided Hen an opportunity to reconsider what was most valuable for students’ learning. His participation in action research group strengthened his belief that mathematics learning should not end with memorization of facts and procedures. Hen claimed the focus of teaching should shift to knowledge exploration and comprehension. He stated students could easily and blindly memorize knowledge that they do not always understand and that they do not retain for long. Memorization in the long term leads to mathematical confusion, frustration, a strong dislike for mathematics, and withdrawal from learning in the long-term. Therefore, in order to involve more students in math learning and transform them to active learners, Hen was convinced that the teaching should shift to help students obtain relational understanding. Based on the findings that Hen acquired from the study, he found the most effective way for students to develop and construct knowledge was through their efforts.
5 Conclusions and Implications

In this chapter, the conclusion of this study is presented, accompanied by a discussion of the implications of active learning and teachers’ professional development. The suggestions for how to overcome the challenges that emerged during the process of creating active learning opportunities for students are subsequently discussed. Considerations for the implementation of this study in future, as well as the contributions and limitations of this research are also highlighted.

5.1 Summary

In the context of this action research study, the question “How do high school mathematics teachers in China create active learning opportunities for their students” was addressed. By introducing the action research cycle, the study captured how teachers incorporate active learning approaches into their daily teaching routine to improve student participation and engagement. The methods that participating teachers introduced to promote active learning, as well as the additional strategies employed to overcome the challenges that teachers faced during the study, were appreciated by the participating teachers as part of their professional development.

The purpose of this study was organized to understand how three participating Grade 10 mathematics teachers in China create active learning opportunities for their students. It centered on detecting the strategies that teachers introduced to improve their teaching. The research
captured different ways the teachers employed to create active learning opportunities for their students. The strategies, which include introducing activities into class, small group cooperative learning, and peer teaching, were introduced by three participating teachers during the research period. However, considering the unique characteristics of the students in each teacher’s class, the ways of introducing these strategies and the additional strategies employed to overcome the emerging challenges during the research differed for each teacher. The perceived challenges that emerged during the process of promoting active learning arose from both teachers and students. For teachers, the main challenge was that they were afraid to delegate authority to students during the teaching and learning process. With regard to students, the challenges include students’ unfamiliarity with active learning strategies, a lack of required skills to help these strategies to function well, and difficulties in adapting themselves to the new roles.

In this action research study, participating teachers’ dynamics attitudes and beliefs toward their teaching and their practices were detected and presented. Thus, in an effort to investigate the research question: “How do high school mathematics teachers in China create active learning opportunities for their students?”, three guiding questions were formulated, which were outlined in chapter one.

1. What approaches have teachers tried and what challenges and successes do teachers report prior to the study?

2. What strategies do teachers try while participating in an action research group?

3. How are teachers’ understanding of their practice changed with their participation in the
action research group?

The results revealed that teachers’ main expectation was to improve their teaching and help their students become more active learners. Teachers believed that becoming active learners could motivate students during the learning process and develop greater interest in math that might give the students the potential for greater academic achievements.

Trying to identify what pedagogical practices and strategies were most effective in actively engaging students was another goal for teachers participating in the study. To prioritize helping students become more active learners, three principles were stressed by participating teachers. First, they believed that active learning didn't just happen but instead required careful planning. Second, they deemed that a successful active learning classroom should be the one that could highly engage and involve students during the learning process. Third, the knowledge students learnt in the classroom should be connected with the mathematics they met in their everyday lives. As such, it would make the new knowledge easier to understand and eventually increase students’ interests.

By participating in the research, teachers’ experiences also revealed their understandings of their own pedagogy, which were influenced or changed after the research. The following themes were captured from each participant’s experiences:

1. Application of active learning principles provided guidance and sources for effective lesson planning.
2. Collaborative reflection and inquiry into research lessons enabled teachers to examine their classroom instructions, revise current practices and obtain new strategies.

3. A shift from traditional teaching method to more active learning approach helped students obtain higher level engagement, greater retention and more active attitudes.

5.2 Implications for school change

The results of this research have the potential to make significant contribution to school change and school improvement. In earlier research on school change, it was shown that substantial school change typically involved the following (Bullough, Kauchak, Crow, Hobbs & Stokes, 1997; Hargreaves & Goodson, 2006):

- Providing opportunities for students to explore the connections between what they learn in school and real life experiences.
- Crediting students’ accomplishments and helping students overcome the barriers they have yet to master.
- Eliminating or minimizing the difficulties that students face in transitioning from one level to the next.
- Accommodating the different ways in which students learn.
- Actively engaging students and enabling them to persist in school despite the challenges they may face.

Clearly, fundamental changes in the school setting occurred as students’ long-term success developed (McLeskey, & Waldron, 2002), which was addressed as the core part of the eighth NCR (Gao, 2013; Wang, 2011; Wu, 2010; Yang, 2004) in China. In addition, if school change is to be successful, development must be made in classrooms to accommodate the needs of different level students that would eventually help students become more active learners (McLeskey & Waldron, 2002).
School changes also have significant impacts on teachers’ professional growth. When school change occurs, it has been shown that lesson planning, teaching methods, related expectations for students’ long-term development, and classroom management patterns also need to be altered (McLeskey, & Waldron, 2002; Milkova, 2012). Changes in the school setting are reflected in altered roles for teachers and typically lead to more teamwork and collaboration environment among teachers (McLeskey, & Waldron, 2002). Teachers’ professional development therefore occurred as a result of these changes.

Based on the results of this study, the dynamic relationship of active learning and teachers’ professional development to school change emerged forcefully from the data. In addition, research on active learning and teachers’ professional development is consistent with the research on school change in general (Taylor, Pearson, Peterson, & Rodriguez, 2005). Therefore, the results of this study and other investigations suggest two major implications for school change: implications for active learning and teachers’ professional development.

5.2.1 Implications for active learning

The results of this study suggest at least two major implications for active learning. First, the results strongly support the effectiveness of active learning in high school mathematics education. The results revealed the fact that teachers need to be very conversant regarding the potential strategies to promote active learning, and they also need to have required skills to adapt these strategies into daily teaching to meet a broad range of students’ needs and eventually transform them into active learners.
In this research, a variety of methods were employed to create active learning opportunities. According to three participating teachers experiences, the main teaching approaches to promote active learning include introducing activity into class, small group cooperative learning, peer teaching, problem-based learning and technology-enhanced learning. Enlightened by the active learning principles listed in the eighth NCR documents, these widely employed approaches shared common features, mainly an emphasis on improving the involvement, engagement and achievement of students during the teaching and learning process. In addition, the introduced strategies typically involve independent inquiry, collaborative learning, self-awareness of students’ own learning and connections to their prior experience, current interests and future goals. These strategies were intended to motivate students and strengthen students’ interest in math, both of which led to greater achievement and helped students become more active learners.

A second implication of this investigation is the significant impact of principles of active learning, which provided guidance and sources for participating teachers to effectively plan and implement research lessons. Principles of active learning helped participating teachers to identify the learning objectives for the research lessons, which helped student develop active relationship with mathematics, instead of just “covering the material”. With the implementation of research lessons, the employment of active learning principles allowed teachers to produce measurable and demonstrable changes in helping students promote active attitudes toward math, building students’ confidence with mathematics problem solving, and bridging the gap between different
Another significant contribution of embracing principles of active learning is their influences on teacher’s individual teaching practices. Firstly, the principles helped teachers to obtain clearer understandings of the introduced strategies and methods. Guided by active learning principles, teachers were more capable of critically examining the effectiveness of introduced strategies and methods in daily teaching routines and eventually strengthen or improve them. Secondly, along with the action research approaches, the application of active learning principles in this study helped the teachers to obtain a clearer understanding of their teaching practices, which allowed them to develop their practices and foster students’ high-level engagement and academic achievements. Thirdly, guided by principles of active learning, teachers adjusted activities that are intended to keep students actively engaged in the learning process and involved as much as possible, the teachers began to focus more substantively on the needs of students with diverse academic abilities in the classroom.

5.2.2 Implications for teachers’ professional development

The results of the study provide support for the powerful effect of action research. In this instance, the exploration of active learning within their classroom also suggests the potential of action research in promoting teachers’ professional development. This is consistent with the findings of Aulls and Shore (2008).

According to participating teachers’ experiences, action research approaches first enabled them to work together to plan specific instructional practices, identify what changes to
implement and determine how to evaluate changes. Coupled with the weekly research team meetings, the action research cycle also provided an opportunity for teachers to bring the previous weeks’ classroom experiences to the table, critically examine individual teaching methods, collaboratively identify problems, and then seek for solutions for the next week. Under such circumstances, the previous week's classroom instructions were examined, current practices revised, and new plans for action formulated. Subsequently, teachers were able to approach holistic understandings of the curriculum within their classroom setting and become critical analysts of their own teaching. Over the course of this study, these experiences allowed teachers to develop professionally.

Second, action research approaches for analyzing teaching methods provided teachers with an opportunity to reconsider what is most valuable for helping students becoming more successful learners. During the study, teachers demonstrated that action research approaches helped them to integrate active learning principles into daily teaching practices and cyclically analyze the introduced teaching methods. Through collaborative reflection and inquiry into introduced teaching approaches, teachers were able to deepen their understandings of active learning principles, and determine how best to apply these theories to practices. Therefore, by providing spaces for peer guidance, opportunities were obtained for teachers to examine, revise, and generate new or adapted practices for their classroom. Through the action research process, teachers could easily recognize how they advanced their professional understandings.

Third the teachers also recognized how the power of collaborative work can both support
and provoke ways of thinking differently about practice. From the results of this research, teachers collaboratively found solutions to classroom challenges and difficulties with other teachers and treated it as an opportunity for their own professional development. Moreover, collaboration among teachers helped them to strengthen the desire to change their teaching approaches. These experiences suggest that collaboration with others depend their understanding of how to create active learning opportunities for students. Teachers’ pedagogical skills, their willingness to share, and attitudes toward student learning were elevated as a result of their work together.

5.3 Suggestions for overcoming the challenges in creating active mathematics learning

Based on identified challenges of creating active mathematics learning in China (outlined in Chapter 1) and three participating teachers’ experiences of creating active learning opportunities for their students, suggestions of how to overcome these challenges are given below.

1. Introducing action research approaches to help teachers better understand and utilize “The Full-time High School Education Mathematics Curriculum Standards” (“The Standards”) to create active learning opportunities for students.

The first challenge mentioned in the ‘Introduction’ chapter was identified as lack of required teaching guides of “The Standards” for teachers to understand and incorporate them into their teaching. First, as previously mentioned, “The Standards” do offer suitable principles for teachers to promote active mathematics learning. But the results of the study
had demonstrated the potential of action research in helping teachers to better understand and utilize “The Standards”. In this study, the action research model was divided into three phases (outlined in section 3.1.3). The scheduled active learning workshops before research lessons were allocated in the first phase. This phase demonstrated the effectiveness of the workshops in helping teachers to understand the principles of “The Standards” when connected with practice at the local level. The shared resources (videos, books, papers and examples of active learning) helped teachers to understand “The standards” during the teachers’ training process also demonstrated its potential for teachers to gain clearer and more focused understanding of “The Standards”.

Moreover, after integrating “The Standards” into daily teaching practices, the practical understandings of “The standards” were shared in research team meetings during the second phase (Creating active learning opportunities). Moreover, the teachers were required to critically reflect and inquiry into their teaching practices by considering the rationality of “The standards” for promoting, in this case, active learning and generating locally relevant strategies to meet their own students’ needs. Under such circumstances, the rationality and criteria behind “The Standards” were fostered for participating teachers to develop comprehensive understandings of active learning. Subsequently, the challenges related to “The standards” were resolved to some degree and provided inspiration for continued exploration.

2. Collaboration among teachers enabled teachers to examine their classroom instructions,
revise current practices and develop new strategies.

The collaborative environment could be an effective way to overcome the second identified challenge “difficulties in finding teaching strategies to promote active learning”. According to three participating teachers’ experiences, they realized it would be useful to reflect collaboratively and inquire into research lessons, which helped them to collectively explore, test, critique, and reflect on strategies to promote active learning. The teachers worked together to plan specific instructional practices, identify the effectiveness of the introduced strategies (or adaptations) to improve their further practice.

3. A supportive school culture in overcoming the pressure from NCEE.

The third identified challenge was also the most significant one, which stems from the invisible control of the National Collage Entrance Examination (NCEE). As a highly selective examination, NCEE is designed as a tool to single out academically strong students who are eligible to receive higher education and it determines the higher starting point when they step into workforce (Huang & Lee, 2013). Exacerbated pressures that come from students, parents, schools and society were applied to students, requiring them to succeed in the NCEE. Therefore, NCEE becomes the most significant challenge in overcoming traditional instructional methods and promoting alternatives that active engage students in their learning with the attendant benefits of increased creativity, imagination, and innovation.

The results of this study suggest that a supportive school culture would be the most effective way to overcome the challenge from NCEE. According to three participating
teachers’ experiences, effective internal support from Renhe High School greatly helped them to implement the new curriculum standards and create active learning opportunities for their students.

With a clear aim that emphasizes teachers’ professional development and curriculum change, Renhe High School provides a variety of supports in curriculum research, development and evaluation. However, the support of the leading administrator, in this case the principal as a critical friend, was a central and highly significant support that not only enabled but encouraged the teachers to experiment with non-traditional practices in a high-stakes testing environment.

5.4 Limitations

There are several limitations in this study. Firstly, this study employed a small number of participants as only three teachers took part in the study. Therefore, the generalizability of the results, the description of each participating teacher’s experience and the generated themes can hardly represent the teachers elsewhere in China. Moreover, as a second level high school in Wuhan, the action research process adopted by teachers in Renhe high school may hardly fit the situation in other level schools.

Further, the length of the study coupled with the constraints of participating teachers’ already heavy workload imposed limitations on the study in terms of duration and intensity. The full extent of the relationship between the changed teaching approaches and active learning may
need to be revealed over a longer period of time. Finally, as the changed teaching approaches were quite new for the students in Renhe High School, the effectiveness of the active learning approach used might largely depend on students’ feelings of novelty toward it during the research period.

Although there were several limitations to the study, the results of the research provide a glimpse into mathematics education reform in China. The results also serve as a springboard for further studies that might probe into teachers’ professional development that supports new and innovative ways of engaging in classroom instruction.

5.5 Considerations for future research

In the particular context of this study, the students in Renhe High School realized the potential for higher academic achievement and engagement via active learning in mathematics. Active learning could lead to positive attitudes, improvements in students’ thinking and enhancements in students’ learning. Moreover, this study revealed that active learning could motivate and engage different academic level students during the teaching and learning process. It also afforded opportunities to students to be academically challenged and eventually led to heightened motivation and engagement. For these reasons, students in Renhe High School were more attracted to active learning than to traditional.

As a pilot study in Renhe high school, the findings of this study urges teachers and school administrators to consider the employment of reform-based teaching modes in Grade 11 and 12
to promote active mathematics learning and make contribution to school change and school improvement. This study draws attention not only to the subject of mathematics, but also demonstrates how active learning approaches could potentially be introduced to other subjects (such as science). In the second stage of “Education Reform Program” in Renhe high school, the active learning approaches and the results of the current study would be introduced and shared in other grades and subjects.

While this study suggests that teachers in Renhe High School can experience a move away from traditional teaching approaches to active learning, a possibility which may subsequently emerge is whether the findings of this research could help promote active learning in elsewhere China. Renhe High School is a typical high school in Wuhan. The findings on how mathematics teachers creating active learning opportunities for their students could be therefore serve to help teachers in other schools. Moreover, as a capital city of Hubei province, the results of the study could potentially be an effective vehicle for teachers in other central cities (such as Beijing and Shanghai) to create active learning opportunities. The potential of active learning could therefore be further developed and might contribute to the limited published research studies in these areas. As mentioned in the third chapter, most of the students in Renhe High School are from working class. Along with the detailed curriculum interpretation and strategies introduced to face the challenges, the results of this study would also have potential to research of active learning in rural areas in China. In this case, it would be significant of contributing to the research of active learning that are lacking in rural areas.
According to participating teachers’ experiences, the current study enabled teachers to work together and to approach holistic understandings of active learning within their classroom setting. In this study, principles of active learning were employed in practices and as a resource to offer teachers new pedagogical skills. With the action research platform, teaching was moved toward more student-centered approaches. Therefore, the results of the study could potentially be a powerful evidence for bridging the gap between principles of active learning and teaching practices. Such a contribution is significant in contributing to the limited published research studies in active learning. Moreover, these experiences would also have significant impacts on teachers’ professional development in elsewhere China.

Importantly, the strength of the current study could also be appreciated as an effort in promoting China’s mathematics education reform. It should not be seen as a final statement of creating active learning opportunities for students in China, but as a pilot study which intend to foster China’s education reform. China has the largest and most complicated education system in the world. If the study could foster the trend of active learning it could help almost 20% of people in the world.
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Appendix A: Main questions of the first set of teacher interview

- In what year did you start working as a teacher?
- When you began to teach in this school? Grade level?
- Why you want join the research? How did you decide to participate?
- What kind of opportunities of professional development you have?
- What does active learning mean to you?
- Do you think active learning is important? If so, why do you think it is so important? What’s the benefit that you see that it has?
- What practices you would like to change?
- What practices you would like to improve?
- What are the strategies that you would use to help students to promote active learning?
Appendix B: Student pre-lesson test

Pre-Research Test

For the questions 1-5, please select one of the four answer choices and write down your choice in the brackets right to each of the question.

1. \( \cos 555^\circ = \)
   A. \( \frac{\sqrt{6} + \sqrt{2}}{4} \)  
   B. \( \frac{\sqrt{6} - \sqrt{2}}{4} \)  
   C. \( \frac{\sqrt{6}}{4} \)  
   D. \( \frac{\sqrt{2}}{4} \)

2. Please simplify \( \cos^2\left(\frac{\pi}{4}\right) \cdot \sin^2\left(\frac{\pi}{4}\right) = \)
   A. \( \sin 2 \)  
   B. \( \sin 2 \)  
   C. \( \cos 2 \)  
   D. \( \cos 2 \)

3. If \( \cos = \frac{4}{5}, \sin = \frac{3}{5} \), what is the quadrant of \( 2 \) ’s terminate side?
   A. First quadrant  
   B. Second quadrant  
   C. Third quadrant  
   D. Fourth quadrant

4. If \( \sin 3x = \sin 2x + \sin x \), which of the following is true?
   A. The equation is true for all values of \( x \) \( R \)
   B. The equation is NOT true for all values of \( x \) \( R \)
   C. The equation is true for infinite values of \( x \) \( R \)
   D. The equation is true for limited values of \( x \) \( R \)

5. If \( \tan = \frac{1}{2}, \tan(2) = \frac{2}{5} \), what is the value of \( \tan(2) \)?
   A. \( \frac{3}{4} \)  
   B. \( \frac{1}{12} \)  
   C. \( \frac{9}{8} \)  
   D. \( \frac{9}{8} \)
6. Please simplify $\frac{\sin(\alpha + 30^\circ) + \sin(30^\circ - \alpha)}{\cos \alpha}$.

7. $ABC$ is an isosceles triangle, $B$ is one of the base angles and $A$ is vertex angle. If $\cos B = \frac{2}{3}$, what is the value of $\sin A$?

8. If $\cos 2 = \frac{1}{9}$, what is the value of $\tan^2 \circ \sin^2$?

9. If $\cos = \frac{\sqrt{5}}{5}$, $\tan = \frac{1}{3}$, $\frac{3}{2}$, $0 \leq \frac{\pi}{2}$, what is the value of ?

10. If $f(x) = \cos 2x \cos \frac{6}{5} - 2 \sin x \cos x \sin \frac{6}{5}$

   1) What is the minimal positive period of $f(x)$?

   2) What is the monotonic interval of $f(x)$?
Appendix C: Student post-lesson test

PART I

For the questions 1-5, please select one of the four answer choices and write down your choice in the brackets right to each of the question.

1. Given the sequence 2, 8, 14, 20, 26, … What is the common difference?
   A. 2  B. 4  C. 6  D. 8
   
2. Find the 41st term in the sequence whose general term is \( a_n = 3 + 4(n - 1) \).
   A. 40  B. 157  C. 198  D. 221
   
3. What is the first term in the arithmetic sequence __, 9, __, 33, 45?
   A. -3  B. -1  C. 3  D. 6
   
4. What is the common ratio in the sequence 12, -18, 27, …
   A. \( \frac{2}{3} \)  B. \( \frac{3}{2} \)  C. \( -\frac{2}{3} \)  D. \( -\frac{3}{2} \)
   
5. The region determined by linear inequality \( x - 2y + 6 > 0 \), is on the ________ side of the line \( x - 2y + 6 = 0 \).
   A. Upper right side
   B. Lower right side
   C. Upper left side
   D. Lower left side
For the questions 5-10, please write down your answers in the blanks.

6. What is the number of the last term shown in the following arithmetic sequence?

-8, 2, 12, 22, 32, 42, 52, ... , 162. \( n = \)___________.

7. In \( ABC,\) \( A = 45^\circ,\) \( C = 30^\circ,\) \( c = 10cm,\) \( a = \)___________.

8. In \( ABC,\) \( A = 60^\circ,\) \( b = 4cm,\) \( c = 5cm,\) \( a = \)___________.

9. Please solve: \( x(9 - x) > 0.\) _________________.

10. Please solve: \( 13 - 4x^2 > 0.\) _________________.

PART II

11. Consider the following linear program:

\[
\begin{align*}
  z = 2x + y, \quad &x \text{ and } y \text{ satisfy the constraints} \\
  \begin{cases} 
  x + 4y &\leq 3 \\
  3x + 5y &\leq 25 \\
  x &\geq 1
  \end{cases}
\end{align*}
\]

What is the maximum and minimum value of \( z? \)

12. Solve:

(1) \( x^2 \quad 3x + 4 < 0 \)

(2) \( (2x + 1)(x - a) > 0 \)

13. In \( ABC,\) \( a = 14,\) \( A = 60^\circ\) and \( b : c = 8 : 5,\) what is the value of \( S_{ABC}? \)

14. In the sequence \( \{a_n\},\) \( a_4 = 9\) and \( a_{n+1} = a_n + 2.\)

(1) Find the general term of the sequence \( \{a_n\}, \) \( a_n.\)

(2) Find the sum of the first \( n \) terms of \( \{a_n\}, \) \( S_n.\)

(3) Find the sum of the first \( n \) terms of \( \left\{\frac{1}{S_n}\right\}, \) \( T_n.\)
Appendix D: Main questions of the second set of teacher interview

- What does active learning mean to you after the research?
- What do you think of active learning now? How you notice in your class related to be active learning?
- What’s the challenge/support of promoting teachers’ professional development?
- Does this research give you an opportunity to do your teaching/class planning differently in the future?
- How did this experience (participation in the action research) help you to learn about your own pedagogy?
- So how different was it the last time you taught it (the chosen unit of the research)?
- Did you have a specific way or system that you used to move your students towards an active learning?
- What advice would you give to another instructor of promoting active learning?
- What is a favorite concrete strategy that you have tried and found to be successful? Why you think it is successful?
- Can you think of anything else that you consider significant about this experience?
- What is your opinion about what are the greatest obstacles to active learning and self-professional development? (How would you improve the situation? At schools in general/in your own teaching?)
Appendix E: “Law of Sines” activity sheet

Consider oblique $\triangle ABC$ shown to the right.

1. Sketch an altitude from vertex A.

2. Label the altitude $h$.

3. The altitude creates two right triangles inside $\triangle ABC$.
   \[
   \sin A = \text{___________}. \quad \sin C = \text{___________}.
   \]

4. Notice that each of the equations in Question 3 involves $h$. (Why does this happen?) Solve each equation for $k$.

5. Since both equations in Question 4 are equal to $h$, they can be set equal to each other. (Why is this possible?) Set the equations equal to each other to form a new equation.

6. Notice that the equation in Question 5 no longer involves $h$. (Why not?) Write an equation equivalent to the equation in Question 5, regrouping $a$ with $\sin A$ and $c$ with $\sin C$.

7. Again, consider oblique $\triangle ABC$. This time, sketch an altitude from vertex C.

8. Label the altitude $k$.

9. The altitude creates two right triangles inside $\triangle ABC$.
   \[
   \sin A = \text{___________}. \quad \sin B = \text{___________}.
   \]

10. Notice that each of the equations in Question 9 involves $k$. (Why does this happen?) Solve each equation for $k$.

11. Since both equations in Question 10 are equal to $k$, they can be set equal to each other. (Why is this possible?) Set the equations equal to each other to form a new equation.
12. Notice that the equation in Question 11 no longer involves $k$. (Why not?) Write an equation equivalent to the equation in Question 11, regrouping $a$ with $\sin A$ and $b$ with $\sin B$.

13. Use the equations in Question 6 and Question 12 to write a third equation involving $b$, $c$, $\sin B$, and $\sin C$.

Consider obtuse $\triangle ABC$ shown to the right

14. Following the steps above (1-13), write three equations involving $a$, $b$, $c$, $\sin A$, $\sin B$, and $\sin C$ of obtuse $\triangle ABC$. 