KOREAN MIDDLE- AND HIGH-SCHOOL MATH TEACHERS’ UNDERSTANDING OF FORMATIVE ASSESSMENT: AN INTERVIEW STUDY

BY

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DISSERTATION

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Abstract

This interview study was conducted to learn about twelve Korean middle- and high-school math teachers’ understandings of formative assessment. Face-to-face semi-structured interviews and field notes were the primary sources for data. I employed an issue-focused analysis to learn about specific issues for each participant (Weiss, 1994) as I examined transcripts and field notes. My overarching research questions are three-fold. First, what are Korean middle- and high-school math teachers’ understandings of formative assessment? Second, what are social, educational, and policy contexts that affect how teachers implement formative assessment practices? Third, how do teachers learn about formative assessment and formative assessment practices?

In this study formative assessment is defined as instructional activities conducted before, during, and after instruction to improve the quality of teaching and to improve students’ capacity to perform subsequent work (Black & Wiliam, 1998, 2009; Stiggins, 2010). Before instruction, the teacher creates assessment tasks or formulates questions. During instruction, the teacher elicits evidence of student learning through observation, interprets elicited evidence through questioning and discussion strategies, and communicates assessment results to students. After instruction, the teacher makes adjustments to subsequent teaching (Black & Wiliam, 1998, 2009; Stiggins, 2010). Another construct under study is discourse-based formative assessment practice (DAP), which is a subset of formative assessment. It happens during instruction, when a teacher gathers evidence of student learning on the spot, interprets student learning by asking additional questions, and makes instructional adjustments in real time.
A significant finding was that Korean teachers were able to distinguish between formative and summative assessments. In teachers’ own words, summative assessment was defined as follows: (a) it is an overall evaluation of students’ academic achievement; (b) it is conducted in the final stage of major instructional periods, such as when a chapter is completed or when a semester is over; (c) it is used to keep detailed records of students’ academic progress.

Another finding was that Korean teachers demonstrated a wide range of formative assessment practices and strategies. In teachers’ own words, formative assessment was defined with reference to the learning objectives and instructional content. It is used to check how well students are comprehending instruction within a class period. It provides helpful information for both teachers and students. For example, students can receive feedback on how they can improve their work, and teachers can improvise during an ongoing lesson and plan next instruction. Korean teachers’ specific examples of formative assessment strategies were clustered around three practices that exemplify DAP.

With respect to educational policy contexts and opportunities to learn about formative assessment, there was a tight connection between government educational policies and teacher professional development programs. Professional development programs helped teachers adopt new educational policies into their practice. Government assessment policies, including standards-based assessment and long-descriptive-written assessment, are explored in detail.

Two things became clear to me as a result of my dissertation study: (a) the important role of professional development programs, and (b) the role of teachers in the
unit schools working hard to implement assessment policies put forth by the government. For future research, I would like to be involved in a professional development programs about formative assessment (FA) and discourse-based formative assessment practices (DAP). Other researchers could pursue teachers’ formative assessment practices in the climate of assessment reform (i.e., standards-based assessment). This study will contribute to the formative assessment literature and secondary math education literature, because there is a paucity of research about Korean teachers’ formative assessment practice in both the Korean and U.S. literature.
To my husband, my parents, and my brother
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Chapter 1
Introduction

Overview

Despite studies that indicate its impact on the improvement of teaching and learning (e.g., Black, Harrison, Lee, Marshall, & Wiliam, 2004; Black & Wiliam, 1998; Wiliam, Lee, Harrison, & Black, 2004), there is paucity of research about Korean middle- and high-school math teachers’ understanding of formative assessment or how it affects their teaching practices and their students’ learning. This dissertation is an interview study of twelve Korean math teachers (seven middle-school and five high-school) in the pursuit of their understanding of formative assessment. My broad overarching research question is this: What is the understanding of formative assessment among Korean middle- and high-school math teachers? In addition, how do the teachers come to learn about formative assessment practices? What are the education policy contexts that affect how they implement formative assessment practices?

Because it is widely understood that formative assessment is effective in improving teaching and learning, it can be claimed that teachers’ increased understanding of formative assessment and their actual implementation of it is promising and necessary. This study will add to literature on the perspectives and constraints that may impact the daily teaching practices of Korean teachers of secondary-school math, and offer policy makers the potential for making more informed policy decisions in addressing educational equity issues that are problematic in the Korean education system.
Background of the Study

My research interest grew out of my prior studies: preliminary study (2011) and pilot study (2012) for the dissertation research. The preliminary study was part of a larger study, “Discourse-based Formative Assessment Practices in U.S. Mathematics Teachers’ Instruction: A Preliminary Study,” funded by The Spencer Foundation, of which Dr. Michele Crockett was the principal investigator. I was involved in conducting classroom-based research, where researchers videotaped American high-school math instruction, transcribed the discourse of classroom teaching, and analyzed the data from formative assessment perspectives. I conducted a case study of one of the teachers involved in the larger study. My research was devoted to understanding the nature of teacher questions and feedback given to students during instruction. This inquiry was important because teacher questioning and feedback are core components of formative assessment practice.

Through my preliminary study, I developed an analytic framework to capture a U.S. high school math teacher’s discourse-based formative assessment practices (DAP). The analytic framework for coding teacher questions was informed by Torrance and Pryor’s (2001) convergent and divergent assessment and Webb’s (2004) three patterns in DAP. The framework used to code teacher feedback was informed by Tunstall and Gipps’s (1996) typology of teacher feedback. An important finding was that teaching and learning is enhanced through a balance of convergent and divergent formative assessment and also through a balance of presenting information and allowing exploration of ideas. These findings in regard to teachers’ DAP practices, including questioning and feedback, informs my dissertation research. In the fifth semi-structured interview in the current study, I ask teachers to examine students’ written work, interpret student understanding
and misconceptions, and provide questions and feedback to students to improve their learning. In addition, I ask teachers to analyze students’ written responses, rank strategies according to their sophistication, and explain reasons to support the rankings. The findings of my preliminary study have helped me analyze the contents of the fifth interview and triangulate the data across the previous interview responses.

In my later study, I sought empirical evidence of the claim that formative assessment improves teaching and learning, drawing from both quantitative and qualitative research. Through classroom-based research I was able to capture the social interaction between a teacher and students and a snapshot of the vivid implementation of teachers’ DAP. Then, I became interested in learning about teachers’ own understanding of formative assessment in general. As a final project in a cultural anthropology methods course, I conducted a pilot study for my dissertation proposal. I interviewed two Korean-American high-school math teachers during fall 2012, three sessions with each teacher. Each interview lasted 60-90 minutes. The interview protocol was developed prior to the interviews. It called for high-school math teachers’ general understanding of formative assessment, their own examples of implementation of formative assessment practices, challenges in implementing formative assessment practices, and teachers’ discourse-based formative assessment practices. In the current study, the interview protocol is informed by the interview questions used in the pilot study.

The Korean-American high-school math teachers used a variety of formative assessment practices such as student group presentation and listening to student explanation, and strategies such as exit slips, learning logs, thumbs-up and thumbs-down, and a fist-to-five. They also used informal formative assessments such as quizzes without
scores, review of homework, and revise-and-retake tests. Additionally, I learned that the teachers gained their practical knowledge from attending workshops and professional development programs that were offered by their school districts. From the pilot study, I learned that it is important to explore what some learning opportunities are for the teachers to gain practical knowledge of formative assessment, and how educational policy impacts teaching practices in regard to formative assessment.

**Statement of the Problem**

Eighth-grade Korean students ranked first on the Trends in International Mathematics and Science Study (TIMSS) conducted in 2011 and second on the TIMSS conducted in 2007. Despite these impressive rankings on the international comparison studies, there is an achievement gap between students from families of high socio-economic status (SES) and those from low-SES families (Oh, 2011; Park, 2007). The achievement differences and its relationship to SES is a concern with the Korean Ministry of Education. Byun and Kim (2010) examined the relationship between SES and student achievement using three most recent TIMSS data (1999, 2003, and 2007) by comparing the results of South Korea and those of the U.S.:

First, although the relationship between SES and student achievement tended to be stronger among the recent cohorts (2007) than among the earlier cohorts (1999) in both South Korea and the U.S., it tended to be stronger among the students in South Korea than among those in the U.S. For example, the influence of SES explained 13% variance in math performance in 1999, and 17% in both 2003 and 2007 in South Korea. In the U.S., the proportions were 10%, 14%, and 13% in 1999, 2003, and 2007 respectively. Second, the influence of SES on student
achievement has increased over time in South Korea. SES was associated with an average performance difference of 25 score points in 1999, 29 score points in 2003, and 32 score points in 2007 in South Korea. This tendency was less evident for the U.S. The corresponding average score differences remained in the range of 17-18 score points. (pp. 173-174)

In Korea, even though the education system is centralized, the competition to obtain more prestigious academic credentials such as high-school diplomas and college degrees is intense because these credentials are valued when students move onto post-secondary education and the job market (Lee, Lee, & Jang, 2010; Lee & Shouse, 2011). For the sake of higher achievement in the public education system and on the College Scholastic Ability Test (CSAT; Sooneung), students rely heavily on “shadow” education. The aim of shadow education is to help students prepare for mid-term and final examinations in their regular schools and for standardized tests that are administered monthly (mock tests) or yearly (College Scholastic Ability Test; Sooneung). Shadow education takes the various forms of one-to-one private tutoring (gaeingawoe), group tutoring (gurupgawoe), for-profit cram institutions (hagwon), home-delivered daily drill sheets (hakseupji), after-school programs in regular schools (bochungsooeup), television programs sponsored by the Educational Broadcasting System (EBS), and Internet lessons (Kim, 2004; Lee, Lee, & Jang, 2010; Lee & Shouse, 2011). Because through shadow education students already have spent intense time at night studying what will be taught in schools, their level of engagement in regular school is low. This has led to the “crisis of mainstream public education” (gongyoyuk boongwoe) (Kim, 2004, p. 524).
Beginning in the 1990s and reaching a peak in 2008, the Korean government’s neoliberal reform policies aimed to reduce the bureaucratic control of the centralized education system and instead increase market control by offering administrative autonomy and flexibility in the public education system (Oh, 2011). It focused on transforming public education into a marketized and privatized system. This led to the overheated “boom of Specialized High Schools” (Park, 2007, p. 1). The reason behind transforming public educational system through marketization and privatization was to create a more equitable system and provide parents and students with various options. Contrary to the government’s expectations, the marketization and privatization led to several detrimental effects (Oh, 2011; Park, 2007). First, market principles decrease educational and social equity, and increase the gap between families of different SES. Second, students from high-SES families get the most out of the marketized education system, while students from low SES cannot afford to make the educational choices. Third, the marketization and privatization create extreme competition among students starting as early as elementary school to gain admission to elite high schools as well as to top-tier universities.

What is the impact on teachers’ formative assessment practices in these educational, social, and political circumstances? Formative assessment is claimed to have the potential to improve instruction and student learning. Black and Wiliam (1998) documented that improved formative assessment helped low-achieving students more than other students and thus reduced the gap between high-achieving and low-achieving students while raising standards overall (p. 141). In other words, formative assessment has the potential to reduce the gap between advantaged and disadvantaged groups. In the
1990s, observations of national assessment policy implementations in the United Kingdom found obstacles in developing policy support for formative assessment (Black & Wiliam, 1998, p. 142). When such obstacles are taken into account, it becomes necessary to find what the assessment policies are in Korea, and whether they foster or hinder teachers in implementing sound formative assessment. In this exploratory interview study, I explore Korean middle- and high-school teachers’ understandings of formative assessment, teachers’ opportunities for learning formative assessment practices, and the impact of current education policy on their practices.

**Research Questions**

Based on findings from the pilot study and taking into account the Korean education policy context, the following themes are developed: (a) Korean middle- and high-school math teachers’ general understanding of formative assessment; (b) the impact of current Korean educational policy on teachers’ formative assessment practices; (c) the role of lesson planning in teachers’ implementation of formative assessment; (d) the role of professional development programs in teachers’ implementation of formative assessment; and (e) teachers’ discourse-based formative assessment practices. I decided to explore lesson planning and teachers’ experiences of professional development programs because I know that Korean teachers plan their lessons as a common practice and that they are required to participate in professional development programs during their summer and winter vacations.

In this study, the primary question is this: What are Korean middle- and high-school math teachers’ understandings of formative assessment? More specifically, I ask the following questions: What formative assessment practices do teachers express in the
semi-structured interviews? What formative assessment strategies do they employ before, during and after teaching? Moreover, how do teachers come to learn about formative assessment practices? What role does professional development play in learning about formative assessment and its use in the classroom? What is the role of lesson planning and of other learning opportunities in teachers’ implementation of formative assessment? Finally, I am interested in the policy contexts in which teachers do their work – more specifically, how Korean math teachers believe that current education policy (social, political, and educational situations) affects their formative assessment practices.

**Significance of the Study**

A growing body of research has explored teachers’ discourse-based formative assessment practices (Chen, Crockett, Namikawa, Zilimu, & Lee, 2012; Crockett, Chen, Namikawa, & Zilimu, 2009; Webb, 2004), and informal formative assessment (Ruiz-Primo & Furtak, 2006, 2007). In a similar line of inquiry, my preliminary study focused on capturing a living implementation of a U.S. high-school math teacher’s formative assessment practices, especially his DAP. However, little research has been done to investigate teachers’ perceptions and understandings of formative assessment. The findings of the dissertation study make a contribution to formative assessment literature that concerns how teachers perceive their own practices in light of their particular social and political contexts. These can be best answered through an interview study.

Finally, this study provides a necessary addition to current secondary math education literature on the perspectives and constraints that may impact the daily teaching practices of Korean secondary math teachers. This study addresses a gap in policy studies in Korean education. This study creates for policy makers the potential for making more
informed and critical policy decisions in addressing educational equity issues that are problematic in the Korean educational system.

**Nature of the Method**

I conducted an interview study of twelve Korean middle- and high-school math teachers. The main data sources are audio recordings of the interviews, transcriptions of digitally-taped interviews, jottings and field notes, teacher handbooks, lesson plan materials, data for local contexts, and policy documents. I conducted five face-to-face semi-structured interviews with each teacher. The first and second semi-structured interviews discussed general questions about teachers’ formative assessment practices, their own definition of formative assessment, examples of formative assessment practices and strategies, the challenges of implementing formative assessment, and the impact of educational policy on formative assessment practices. The second and third semi-structured interviews expanded on the teachers’ answers from the previous interviews, and supplemental questions that arose were asked. In addition, I asked them about opportunities for learning about formative assessment such as professional development programs and workshops, the structure and contents of the workshops and other professional development experiences, and their impact on teachers’ instruction. The fifth semi-structured interview sought responses to teachers’ discourse-based formative assessment practices. The data from the fifth interview helped me triangulate data across previous interviews.

The answers were analyzed qualitatively. By consulting books about methods of qualitative interview studies (Weiss, 1994), I conducted an issue-focused analysis because I wanted to learn about specific issues from all participants, in comparison to a
case-focused analysis where the individual case is the focus. I was involved in three analytic processes in the issue-focused analysis: sorting, local integration, and inclusive integration. I cut interview transcripts and field notes in topical units, developed mini-theories or working hypothesis to integrate some areas, and, finally, developed a framework that includes all of the analysis to create a single coherent story, which leads to a conclusion.

**Introducing Key Terms**

The key terms in this study will be elaborated in the following chapter. They are: formative assessment (i.e., assessment *for* learning), discourse-based formative assessment practices (DAP), benchmark and interim assessment, summative assessment (i.e., assessment *of* learning), and performance assessment. There are distinctions among three levels of assessment: formative classroom assessment, benchmark and interim assessment, and summative assessment (Arter, 2010; Perie, Marion, & Gong, 2007; Shepard, 2008). They are on a continuum in terms of the frequency of their implementation. Educational researchers and teaching practitioners have not arrived at a consistent definition of classroom assessment terminologies or what these practices look like (Frey & Schmitt, 2007). In exploring classroom assessment terms, however, it is important to note how they differ from each other in terms of components, formats, and intentions.

While the forms of formative assessment mentioned above inform this study, the primary focus is on classroom assessment, or formative assessment, more specifically, since it pertains to teachers’ instructional practices more directly. For example, the formative assessment under study is most frequently administered minute-by-minute and
is integrated into the lesson. It is conducted during instruction when teaching and learning are still happening for the purpose of improving teaching and learning. Formative assessment is used “to provide feedback to the teacher to assess the quality of instruction and to improve teaching behaviors, or to provide feedback to the students to assess the quality of learning and to improve learning behaviors” (Frey & Schmitt, 2007, p. 417). Examples of formative assessment include and are not limited to the following: observing, reviewing quizzes and students’ work, conducting diagnostic interviews, engineering effective questioning, providing content-specific feedback both written and oral, sharing rubrics for success criteria, displaying exemplary work from previous years, and having students assess themselves and their peers (Black & Wiliam, 2009; Pryor & Crossouard, 2008). When the focus is particularly on the behavior of students, it is called assessment for learning (Stiggins, 2002). The feedback provided by teacher needs to be used by the students to narrow the gap between where they are and where they aim to be.
Chapter 2

Literature Review

In this interview study, my overarching research questions are the following:

What are Korean middle- and high-school math teachers’ understanding(s) of formative assessment? More specifically, what are the formative assessment practices that the teachers identify? What formative assessment strategies do they use before, during and after teaching? Moreover, how do the teachers come to learn about formative assessment practices? What role does professional development play in their learning and implementation? And, what is the role of lesson planning and other learning opportunities in teachers’ implementation of formative assessment? Finally, I am interested the policy contexts in which teachers do their work. I asked Korean math teachers how they feel that current education policy (social, political, and educational situations) impacts their formative assessment practices.

Torrance and Pryor (1998) documented the role of the United Kingdom’s assessment policy on teachers’ practices. In their interviews with teachers in the U.K., they found a difference between an assessment that is influenced by a “political concern for accountability” and another kind of assessment that grew from an “educational concern for learning.” With “teacher assessment” touted in the U.K., teachers need to produce a valid and reliable record of individual student’s performance matched to the levels of the National Curriculum. In contrast, teachers also conducted daily assessment in the context of ongoing classroom interaction that consists of observation, questioning, and discussion.
Torrance and Pryor (1998) asked U.K. teachers “what was implied by ‘teacher assessment’ and how they attempted to put it into practice in their own classrooms” (p. 21). Teachers have always assessed and monitored students’ performance and their progress, but with the new educational policy in the U.K. teachers were required to formalize their assessment practices by providing detailed evidence collected in relation to the National Curriculum, as it was applied in 1990s. “Assessment was perceived as a formal activity oriented to producing valid and reliable summative measures of performance, and teacher assessment was assumed to be part of this process” (p. 23).

First, teachers planned their instruction and organized academic resources into the progression of the National Curriculum. Head teachers then reviewed teachers’ planning sheets and files to be sure that formal assessments would be accomplished weekly. Second, teachers conducted assessment by observing, listening, and questioning students. Third, teachers recorded assessment and retained evidence by filling in the National Curriculum grid. “The purpose was to produce periodic, cumulative evidence that National Curriculum attainment targets had been achieved” (p. 32). “The orientation was to produce summative assessments for third parties rather than conduct formative assessments to support teaching and learning” (p. 33).

In contrast, with further interviews, teachers acknowledged the importance of informal classroom assessment and their motivation to listen to, get to know, and teach students on a daily basis. They described glimpses of routine classroom assessment with much more diagnostic and formative orientation. Apparently, there is a gap between what teachers perceived as government intentions and their everyday routine assessment interactions with students. Similarly, when teachers hear the words “classroom
assessment,” they are instantly reminded of “test construction strategies or item-writing rules that they create for their own tests” (Frey & Schmitt, 2007, p. 404). More specifically, when teachers are asked how they assess their students, they are likely to cite “tests, quizzes, portfolios, projects, and other formal methods” (Wiliam, 2007, p. 1053). In contrast, when they are asked how they know whether their students have learned something, they mention “classroom questions, group activities, discussions, posters, concept maps, and the expressions on the faces of their students” (p. 1053), most of which are informal methods of assessment. My study is similar to Torrance and Pryor (1998) in that I also want to understand how educational policy in Korea affects teachers’ everyday assessment practices and their perception of the government’s intentions.

Torrance and Pryor (1998) capture vividly how U.K. teachers felt that the change of educational policy affected their daily formative assessment practices. The new “teacher assessment” policy pushed teachers to formalize their assessment practices by filling in the grids of the National Curriculum to produce reliable and valid evidence and to keep detailed records of student achievement. Some teachers resisted the frequent changes of government policy while others adjusted and took a chance on the change. Thus, the Torrance and Pryor study calls attention to the factors that affect how teachers respond to government policies. Accordingly, this study is situated in the Korean political context. Informing the study are three kinds of literature: formative assessment, classroom discourse, and professional development.

**Korean Education Policy Context**

Educational researchers at the Korea Institute for Curriculum and Evaluation (KICE) categorized the Korean educational assessment system as consisting of three
main areas for the purpose of their survey research: (a) student assessment at school level (haksaeng peunga), (b) college entrance examination system (daeip jaedo), and (c) national-level student achievement evaluation (kukga sujoon hakeup seungchido peunga). Whereas the latter two are administered at the national level, the student assessment area is at school or instructional level. The researchers identified three components of student assessment at school level: (a) the archive of student academic report cards (hakkyo saengwhal kirokbu), (b) performance assessment (suhaeng peunga), and (c) grading students’ achievement into nine levels (naesin gu deungup jae). All three components of student-assessment are concerned with producing formalized scores for recording student achievement to be used for college entrance. These components do not address the kind of formative assessment practices that are the focus of the present study.

KICE researchers worked with the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) center at the University of California at Los Angeles (UCLA) to implement formative assessment programs at the instructional level. The purposes of their research was three-fold: (a) to analyze the impact of lesson planning, (b) to analyze the effectiveness of feedback in the formative assessment program, and (c) to propose policy directions for the improvement of teaching and learning with regard to formative assessment practices. Their findings suggest, first, that instructional practice that provides content-specific feedback is effective, and, second, that the lesson planning material developed by the individual teacher reflecting the characteristics of the teacher and his/her own students is more effective than the prescribed lesson planning provided by the program developer (Korea Institute for Curriculum and Evaluation, 2010).
KICE further proposed some policy directions. First, professional development programs should be encouraged that are focused on disseminating the practices and strategies of formative assessment. It is the case that the majority of Korean teachers understand formative assessment in a general way without having the resource of specific and concrete examples of formative assessment practices and strategies to be able to implement them in their teaching. Second, formative assessment programs should be developed at the national level to be distributed. Since teachers need the development of formative assessment tasks, analytic tools for examining assessment results, and the course preparation for subsequent teaching based on the assessment results, it would be effective and wise to accumulate all the useful data and make the database sharable for the teachers. Third, the pre-service education system should be innovated so that teachers’ abilities to adjust their instruction and their determination to adopt effective instructional strategies are fostered at the earliest stages of their teaching careers (Korea Institute for Curriculum and Evaluation, 2010).

These KICE proposals prompt several interview questions regarding teachers’ opinions about the proposals and how they impact their instructional practices—for example: What has been the role of professional development for learning about formative assessment? What formative tasks and analytic tools have been provided and how have they been used? How do teachers describe the student grade-management system in their schools? Questions concerning some specific governmental policies are as follows: Do you feel that the policy regarding College Scholastic Ability Test (CSAT; Sooneung) is affecting your teaching? How and why? Do you feel that the private tutoring (hagwon) fever is affecting your classroom? How and why?
Formative Assessment

Conceptualizing Formative Assessment

Formative assessment is the central construct in this study. Stiggins (2010) and Black and Wiliam (2009) inform its conceptualization. First, formative assessment can be broadly framed as having a two-part component: (a) competence in creating quality assessment and (b) competence in productive use of the assessment (Stiggins, 2010). The competence in creating quality assessment has three steps, while the competence in productive use of assessment has two. The competence in quality assessment has three steps to ensure the accuracy of assessment results. The first step is to have clear purpose of who will use the results. The second step is to specify clear learning targets as to how student performance will be assessed compared to the standards. The third step is to design a sound assessment, whether it is “a multiple-choice item, written response, performance assessment task, or personal interaction with the student” (p. 238). The competence in productive use of assessment has two steps to ensure that the assessment process and its results will be used productively to promote student learning. The first step is effective communication of attributes of student’s work to inform how their work can be revised and improved the next time. The second step is student involvement on assessing and monitoring their own progress.

This model emphasizes creating high-quality assessment tasks and communicating the results to students to guide them in improving their work. It describes the work that has to be done by the teachers while planning assessment tasks and communicating the results to their students. While it describes the processes done by teachers before and after instruction, it does not specify what happens during instruction.
when students are at work and while teachers are gathering evidence of student learning and interpreting the assessment information.

Second, in their seminal research on exploring the effectiveness of formative assessment practices, Black and Wiliam (1998) reviewed empirical articles that cover a broad range of classroom practices and learning theories such as self- and peer-assessment, mastery learning, feedback, intrinsic motivation, learning and performance goals, and working with children with disabilities. For the purpose of their study, they interpreted formative assessment in a broad way:

It is interpreted as encompassing all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged. (p. 7)

The definition is focused on two actions: (a) The student recognizes a gap between current and desired performance, and; (b) the student takes an action to close the gap (Brookhart, 2007). It is only when the student takes an action to close the gap between the actual level and desired level that the feedback is considered formative (Ramaprasad, 1983). In their review, Black and Wiliam not only saw the importance of formative assessment practices, but also found the need to conceive formative assessment within a larger frame of pedagogy.

Black and Wiliam (2009) refined their definition of formative assessment as follows:

Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or
better founded, than the decisions they would have taken in the absence of the evidence that was elicited. (p. 9)

In the above definition three things stand out. First, whereas Stiggins (2010) interprets formative assessment as having two components (competence in creating quality assessment and competence in productive assessment use), Black and Wiliam (2009) suggest that formative assessment involves three components: evidence elicitation of student learning, teacher interpretation of the evidence elicited, and using them for subsequent instruction. This process fills the gap between creating sound assessment tasks and communicating the assessment results to students, as described by Stiggins (2010). Black and Wiliam (2009) address more specifically what happens during instruction when teachers are actually eliciting evidence of student learning and interpreting the assessment information they have gathered. Second, there are three agents of assessment: teachers, learners, and peers. Not only teachers make adjustments to instruction, learners themselves and their peers also actively use the feedback they receive from their teacher and peers, and self-regulate to make their learning experience more valuable. Third, formative assessment is about making decisions about subsequent instruction. Teachers can not only provide feedback to their students to move them forward, but also use the assessment outcome so that they can modify the instruction to make it more effective.

Taking into account the above definitions of formative assessment (Black & Wiliam, 1998, 2009; Stiggins, 2010) and for the purpose of the study, I take formative assessment to be an educational practice that is administered before, during, and after instruction to improve the quality of teaching and to improve students’ capacity to
perform subsequent work. Before the instruction, the teacher creates high-quality assessment tasks. During the instruction, the teacher elicits student learning through careful observation of students at work and through effective questioning and discussion strategies. The teacher continuously interprets the evidence gathered of student learning. In addition, the teacher communicates assessment results to students and guides them to improve their work through comments and feedback. After the instruction, the teacher strives to make adjustments to subsequent instruction as necessary. Formative assessment involves peer assessment as well as student self-monitoring of their progress.

Socio-cultural theories of learning and teaching undergird the conceptualization discussed above. For example, Pryor and Crossouard (2008) defined formative assessment as embedded in classroom interaction, where “teacher and students respond to students’ work with the intention of improving students’ capacity to do subsequent work” (p. 3). They envisioned that the practice of formative assessment would entail changed classroom norms, that it is a good fit with constructivist learning theory, and offered a conceptualization of formative assessment that takes into account socio-cultural learning theories. There is a contrast between assessment practices influenced by behavioristic models, which dominated the twentieth century and continues to affect current practices, and those which are influenced by social-constructivist models of teaching and learning, which are more current (Shepard, 2000). In the behavioristic model, instruction and assessment are seen as separate. In other words, assessment is seen as “an official event, separate from instruction” (p. 5) and has to be objective and impartial. In a social-constructivist model, learning is seen as an active process of knowledge construction and sense-making. Coherent ways of thinking and representing problems are emphasized
rather than mere accumulation of information. Whereas curricular reforms have changed the ways of instruction to embrace the social-constructivist model, assessment practice is still influenced by the behavioristic model. Shepard’s main argument is that “assessment should be changed to be consistent with the social-constructivist model” (p. 4). She suggests that the “form and content of assessment should be changed to require higher-order thinking such as problem-solving skills” and that “the way assessment is used in classroom and how it is regarded by teachers and students must change” (p. 7).

After research among classroom teachers, Pryor and Crossouard (2008) found that most classroom assessment was characterized as convergent, and they only occasionally observed divergent classroom assessment. These do not represent either good or bad practices, but can be seen as ideal types that are placed at each end of a continuum (p. 6). Convergent formative assessment is used when teachers check with students to determine whether they have acquired a specific learning target by asking closed questions that require short answers. The teachers already have in mind what counts as correct responses and provide hints and suggestions to lead students to the expected answer. In other words, the teachers get students to acquire a specific procedure as outlined by a textbook or agenda for them to appropriate. The feedback teachers give is often authoritative and judgmental. Below is an example of two-digit addition with regrouping. Chen, Crockett, Namikawa, Zilimu, and Lee (2012) use it to illustrate typical exchanges in many classrooms. This exchange can also be viewed as behavioristic or as a convergent assessment exchange between teacher and students.

Teacher: What is 23 plus 8?

Student: 30
T: That's incorrect. Who knows the correct answer?

Ss: 31.

T: Great. Let’s move on to the next problem.

(Excerpt taken from Chen et al., 2012, p. 556)

Divergent formative assessment is used when teachers have students explain, restate, or elaborate on their problem-solving strategies by asking open-ended questions. This time, the goal is not merely in checking to see whether students have mastered a certain train of thought and whether they are able to apply that knowledge in solving similar problems. Rather, the goal is to give students an opportunity to demonstrate their current levels of understanding (that is, what they know, understand, and can do). The students are engaged in higher levels of thinking that involve explaining, justifying, arguing, and reconstructing their understanding. Teacher feedback is more exploratory, provisional, and provocative. Chen et al. (2012) use the example below to illustrate a social-constructivist approach to teaching and learning. It can also be viewed as a divergent assessment exchange between teacher and students.

T: What is 23 plus 8?

S: 30

T: Why do you think it’s 30?

S: Because … (not finishing his thought)

T: Because what? (Teacher is prompting him to answer).

S: Oh. I messed up.

T: Where did you mess up?

S: Three plus 8 is 11. That’s where I messed up. Twenty plus 10 plus 1
Teachers may construct assessment task or engineer classroom discussion with a clear instructional purpose in mind. They might have in mind to check whether students have learned a certain process or a mathematical definition that was taught previously. Or, they might intend to explore students’ mathematical thinking, their reasoning and justification for solving a problem certain way. Pryor and Crossouard’s conceptualization uncovers teachers’ hidden instructional intentions, and captures what happens during instruction, on the spot, synchronously. It is closer to instructionally-embedded assessments that will be discussed in the following section.

**Discourse-based Formative Assessment Practices (DAP)**

Researchers from different areas explored alternative interpretations of formative assessment. Different terms are used, such as proximal formative assessment (Erickson, 2007), instructionally-embedded or discourse-based formative assessment practices (DAP) (Chen, Crockett, Namikawa, Zilimu, & Lee, 2012; Crockett, Chen, Namikawa, & Zilimu, 2009; Webb, 2004), and informal formative assessment (Ruiz-Primo & Furtak, 2006, 2007). Such assessment happens during instruction, when a teacher gathers evidence of student learning on the spot, interprets student understanding or misconceptions, and synchronously makes instructional adjustments in real time.

Erickson (2007) introduced the concept of proximal formative assessment to describe the process of teaching and learning where “learning is monitored during the course of its development” (p. 202). The teacher “alters instruction according to the assessment information they gathered through observation of student engagement in an
activity or close examination of student work” (p. 202). It is a definition that highlights the ways in which a teacher elicits and collects evidence of student learning:

It is a process in the ongoing course of instruction between students, classroom materials, and the teacher. … It is a continual “taking stock” that teachers engage in by paying firsthand observations attention to students during the ongoing course of instruction – careful attention focused upon specific aspects of student’s developing understanding and mastery of skills, as instruction is taking place in real time. (p. 187)

The teacher elicits and collects evidence of student learning by various means – talking, writing, analytic drawing, modeling, tables, and charts. If a student’s understanding is incomplete, or the crucial skill has not been acquired, the teacher intervenes to provide further instruction until the key skill is mastered. The teacher compares the level of student understanding to the desired level, and uses the evidence gathered to inform next instructional moves.

While Erickson’s (2007) definition of proximal formative assessment highlights the importance of the process of eliciting evidence of student learning, Webb’s (2004) definition of discourse-based formative assessment practices (DAP) incorporates the subsequent two steps of interpretation and usage of the assessment information gathered. Emphasizing the use of classroom discourse in supporting student learning, Webb defines DAP, where a teacher

(a) monitors student progress or misconceptions, (b) solicits additional information through probing, guiding, and reframing of questions, and (c) communicates expectations for mathematically valid representations. (p. 170)
In the first process (monitoring student learning), the teacher elicits and collects evidence of student learning through careful observation of students’ written work or their interaction in small groups and/or the whole group. The second and third processes (soliciting additional information and communicating assessment results) is related to teachers’ interpreting and using evidence collected to improve the quality of student work.

Most conventional teacher-and-student classroom interaction can be characterized as teacher initiation, student short response, and teacher evaluation/feedback (IRE/F), a tripartite sequence (Hoetker & Ahlbrand, 1969; Sirotnik, 1983), whereby teacher talk dominates the classroom discourse. Mehan (1979) and others (Cazden, 2001; MacBeth, 2003) have characterized classroom discourse as IRE/F sequences. More recently, Webb, Nemer, and Ing (2006) revealed that pedagogical practice remained unchanged two decades later despite recommendations for reform. In contrast, when teachers employ formative assessment practices during instruction, the third move in the IRE/F sequence “solicits additional information through probing, guiding, and reframing of questions” (Webb, 2004, p. 170). In the extended sequence, there is more room for teachers to investigate student understanding, their own reasoning, and argumentation.

Ruiz-Primo and Furtak’s (2006, 2007) construct, “assessment conversation,” is similar to the extended sequence. An assessment conversation means daily instructional dialogues where assessment is embedded into classroom activities. It is characterized as a series of ESRU cycles. First, a teacher asks a question to elicit student thinking. It allows students to share and exhibit their understanding. Second, a student responds. Third, the teacher recognizes the student’s response. The teacher acknowledges student’s contribution by restating the student’s comment to the class, and comparing it to the
learning goal. Fourth, the teacher uses the information gathered to support student learning. The teacher takes action to move students towards learning goals by providing specific information on actions students may take to reach learning goals, or by asking another question that challenges or redirects students’ thinking. Ruiz-Primo and Furtak (2006) defined informal formative assessment as a kind that involves “gathering, interpreting, and acting on” (p. 206) information about student learning so that teaching and learning can be improved.


**Theorization of Formative Assessment**

Most often formative assessment is taken to mean “assessment for learning.” That is, the focus has turned to the instructional practices of teachers as they teach. Black and Wiliam (2009) provide an elaborated theory for this focus. Black and Wiliam conceptualized formative assessment as involving three agents (a teacher, learners, and peers), who are engaged in three processes: (a) actual level (where the learners are); (b) reference level (where they are going); and (c) closing the gap between the two levels (what needs to be done to get them there) (Black & Wiliam, 2009; Ramaprasad, 1983). Combining three processes with three agents, Black and Wiliam theorized that formative assessment consists of five practices, as shown in Table 1.
The first practice is “clarifying, sharing, and understanding learning intentions and criteria for success” (Wiliam, 2010, p. 32). Teachers specify learning intentions in terms of clear goals and narrowly defined criteria. Although sometimes it is not possible to have clear goals and narrow criteria, teachers can redirect students’ activities if they judge that certain activities do not lead to meaningful learning. The second practice is “engineering effective classroom discussions, activities, and tasks that elicit evidence of learning” (p. 32). Although questioning is used most frequently to elicit evidence of student learning, any actions that elicit evidence that could be used to inform instruction can be included. These activities may include “classroom questions, group activities, discussions, posters, concept maps, observations of student work, and even facial expressions of their students” (Wiliam, 2007, p. 1053). The third practice is “providing feedback that moves learners forward” (Wiliam, 2010, p. 33). The feedback is effective when it is prospective rather than retrospective. It is effective when it is centered on a task, on the process of completing a task, and on self-regulation. It is not effective when
it is centered on the person. The feedback is not only be provided to the students but also used by the teacher so that he/she can improve the quality of instruction. The fourth practice is “activating students as owners of their own learning” (p. 34). This is related to the self-regulated learning model. Students who are on a growth track pursue learning goals to increase competence. Students who are on a well-being track, on the other hand, pursue performance goals and prioritize friendship, and their learning is compromised. The fifth practice is “activating students as learning resources for one another” (p. 35). Assessing other’s work can be easier than assessing one’s own work, and being involved in peer assessment can eventually lead to effective self-assessment and self-regulation.

In a different perspective, the above theorization of formative assessment consists of three parts: where the learner is going, where the learner is at present, and how to get there. First, the teacher and students share the learning targets at the beginning of a lesson or a unit for the students to have a clear idea of the learning goal they should achieve and for the teachers to have a general idea of students’ learning progressions. Second, the teacher gathers evidence of student learning to understand where the learners stand in the learning progression, and to check whether the students are struggling with a particular concept. Third, the teacher uses all the evidence elicited to get students to achieve the learning goal. He/she might engineer a whole-class discussion to move student thinking forward or tell the students directly how their work could be revised and improved.

This theorization provides a range of the formative assessment practices that teachers may employ at the instructional level. It broadens the perspective that I developed about the definition of formative assessment, and gives me a framework for developing interview questions to help me answer research questions. It is worthwhile to
differentiate five key practices described above from strategies (Thompson & Wiliam, 2008). In addition to the five practices in the formative assessment theoretical framework, the strategies represent specific and concrete methods that a teacher can employ.

For the first practice (clarifying learning intentions and sharing criteria for success), examples strategies could be sharing exemplar student work or a teacher-made mock-up. Or, it is useful to have several students at the end of instruction report something that they learned taking thirty-second turns (p. 7). For the second practice (engineering effective classroom discussion, questions, and learning tasks that elicit evidence of learning), example strategies could be using “ABCDE cards” or “colleague-generated questions” (p. 8). Teachers pose multiple-choice questions and ask students to hold labeled cards. Or, the teachers could share with their fellow teachers some good questions that require higher-order thinking to be used in their own classrooms. For the third practice (providing feedback that moves learners forward), example strategies could be “comment-only marking,” where the teacher provides only comments without scores or grades on student work. Or, the teacher might mark student work with plus, minus, or equals sign to compare current student performance with earlier (p. 8). For the fourth practice (activating students as the owners of their own learning), example strategies could be “traffic lighting” to identify students’ own levels of understanding through green (understand), yellow, or red (don’t understand). Another strategy is to have students keep “learning logs” in which they summarize their reflections on what they learned in the class session (p. 9). For the fifth practice (activating students as instructional resources for one another), example strategies could be involving students to trade papers and check each other’s work to improve the quality of their own work before submitting to
the teacher (p. 9). Or, students may post the homework questions that they struggle with and get their peers to help solve them.

**Challenges to Implementation**

Formative assessment is little studied and under-theorized for several reasons (Erickson, 2007). First, after the teacher gathers assessment data through observation of student engagement in an activity and of their written work, he or she might not know how to “interpret” the assessment information. Further, the teacher might not know how to “use” the information to inform some instructional change. In their study investigating teachers’ abilities to adapt instruction based on assessment of student knowledge and understanding, Heritage, Kim, Vendlinski, and Herman (2009) found that while teachers do better at drawing inferences of student levels of understanding from assessment information, they can have difficulty in determining the next instructional steps. In other words, planning further instructional steps based on the evaluation of students’ understanding tended to be more difficult for teachers than identifying key principles of the assessment task and evaluating student understanding. To remedy this, teachers need to possess pedagogical content knowledge to understand the implication of assessment data, and use their “professional clinical judgment” (Erickson, 2007, p. 190) to alter their approach to instruction.

Second, there are pressures from outside the classroom (Erickson, 2007). For example, teachers might feel pressured to follow their schedule strictly to ensure their students learn what they are supposed to learn in a timely way. Saxe, Gearhart, Franke, Howard, and Crockett (1999) explored how math teachers’ methods of assessment shift over time in relation to the pressures of “institutions (standards, curricular materials,
district testing, and professional development programs), key stakeholders (parents, administrators, colleagues, and students), and teachers’ own internal pressures” (p. 86). They observed the exercises and open-ended problems being used for eliciting student performances, as well as the use of scores and rubrics for evaluating student performances. Exercises and scores represent old forms of assessment, while open-ended problems and rubrics represent new forms of assessment. Pressures encouraging the use of exercises (old form) were curricular materials, district testing, students, and parents (p. 93), while pressures for open-ended problems and rubrics (new forms) were mostly professional development programs and students (pp. 93-94).

In responding to the external pressures, teachers adopted new assessment forms that are designed to serve new assessment functions. Exercises were most frequently used, followed by open-ended problems and rubrics. Exercises were stable in use, while open-ended problems and rubrics were increasing in their implementation. In the two cases, a teacher used new forms of assessment, such as open-ended problems and rubrics, to serve old functions of evaluating students’ answers as either right or wrong and to score student responses. There was a shift in form, but not in assessment function. While the teacher attempted to adopt the new forms of assessment, it was difficult for her to change instructional practices and intentions. The other teacher used new forms of assessment, open-ended problems and rubrics, to serve the new function of eliciting and analyzing students’ mathematical thinking. Exercises (old form) were supplemented with written explanations of procedures to help her identify student thinking (new function). It is important for educational researchers to help teachers not only in disseminating the new
forms of assessment but also in supporting them in learning how to use the new forms of assessment along with the new, reform-oriented practices.

Third, there is a long-held belief that student learning cannot be assessed validly through teachers’ firsthand observation, and that the measure by testing provides more valid and reliable results for gauging student learning (Erickson, 2007). Watt’s 2005 study illustrates this point well. She investigated “teachers’ use of alternative methods in math classrooms, attitudes about using alternative assessment methods, and impediments using alternative methods” (p. 21). The study was conducted in New South Wales (NSW) in Australia, where teachers’ views are conservative in regard to curriculum and assessment. Watt “explored these teachers’ views, identified the range of assessment practices they use, and examined what encourages or constrains their practices” (p. 23). In addition to traditional math tests, the researcher explored the use of newer forms of alternative assessment such as “oral tasks, practical tasks, teacher observation, student journal, student self-assessment, and parental assessment” (p. 26). These were suggested in NSW math curriculum.

Watt hypothesized that teachers resist or become indifferent to alternative forms of assessment are because of “the desire to maintain the high status of math subjects in the society, of the deeply embedded beliefs of teaching math, and of belief that alternative assessments are subjective” (pp. 24-25). The survey results suggested, first, that teachers are satisfied with traditional math tests. The least experienced teachers are least satisfied with the traditional tests, and the most experienced teachers most satisfied. Second, among the alternative assessment forms, oral tasks, practical tasks, and observations are frequently used, while student journals, student self-assessment, and
parental assessment are infrequently used. Third, the reasoning against using alternative assessment is that teachers regarded it as too subjective. This was the concern raised by teachers across all lengths of teaching experience. Fourth, the main methods of assessment were traditional math tests, followed by assignments and observations, which are alternative assessments. Fifth, while lower-grade math curriculum permits the utilization of alternative assessment methods, the upper-grade still does not. Sixth, when asked about suggestions for curricular modification for more alternative assessment methods, teachers suggested making the curriculum less exam-driven and changing existing teaching methods by introducing group work and practical work to permit alternative assessment methods. The findings suggest that reform efforts must address teachers’ perceptions of alternative methods as unreliable and subjective.

Finally, there is a heavy influence of the assumptions that are aligned with summative assessment, that learning happens after teaching and instruction is completed (Erickson, 2007). An alternative conception that can support formative assessment is that learning happens within the ongoing course of interaction of teaching and learning. In the first semi-structured interview, I will ask teachers about the challenges of applying formative assessment strategies in their classrooms.

**Is Formative Assessment Effective?**

According to Black and Wiliam’s 1998 meta-analysis of the literature, formative assessment improves student learning, especially that of low-achieving students. They found evidence in many studies that formative assessment has a beneficial effect particularly on disadvantaged and low-attaining learners. They concluded that significant learning gains are attainable when teachers employ formative assessment practices in
their classrooms. The gains in achievement are mountable to an effect size of 0.4 – 0.7. When it is considered in national-wide scale, the effect size of 0.7 is equivalent to raising the international math scores of an average country into the top five.

The review is dated. However, a more current study (Wiliam, Lee, Harrison, & Black, 2004) indicates that improving formative assessment does produce tangible benefits in terms of externally mandated assessments, such as Key Stage 3 tests and GCSE examinations in the U.K. Wiliam et al. (2004) employed a professional development program at six schools in the U.K. They encouraged math and science teachers to use strategies such as rich questioning, comment-only marking, sharing criteria with learners, and student peer-assessment and self-assessment. Researchers made use of assessment instruments administered by the schools, such as national school-leaving examinations (GCSE), and school assessments, as input and output variables in their experiment. Their estimated effect size was 0.32, which implies that improvements equivalent to one-half of a GCSE grade per student per subject are achievable. If replicated across a whole school, the performance of a school in the bottom quarter of achievement would be raised nationally into the upper half. Their research shows that substantial learning gains are obtainable when teachers employ formative assessment strategies, and that these gains are indicated by external, objective tests. Their study shows how improvement in teachers’ formative assessment practices impacts learning gains. Both studies—Black and Wiliam (1998) and Wiliam et al. (2004)—support the argument that improving formative assessment practices has an impact on raising student achievement.
There are researchers (Wiliam, 2010) who urge caution in relying on standardized effect sizes in educational studies. Torrance (2012) raises the tough question of whether the effectiveness of formative assessment should be evaluated through external measures such as tests and public tests, and whether the increases in such scores indicate genuine improvement in learning. He claims that improvement in test scores do not necessarily mean real improvements in learning. He criticizes the current educational phenomenon whereby formative assessment is used to improve test scores and examination grades, rather than to improve the quality and experience of learning.

In their mixed-methods empirical study using both qualitative and quantitative approaches, Ruiz-Primo and Furtak (2006) aimed to capture what informal formative assessment looks like in real classrooms, so that it may be used to improve pre-service training and professional development programs. They identified levels of teachers’ informal assessment practices, and linked levels of informal assessment practices to levels of student learning (p. 207). Four middle-school science teachers were involved in the study, in which their students investigated concepts of mass, volume, and density, as well as the relationship between density and buoyancy. Videotapes of forty-nine lessons across the four teachers were collected. The teachers’ assessment conversations took the forms of complete ESRU cycles, incomplete ES or ESR cycles, and cycles initiated by students. Student embedded assessments included graphing and Predict-Observe-Explain (POE) assessment. Graphing requires students to summarize, represent, and interpret data. POE assesses student understanding about density and relative density. Students predict whether an object would sink or float, and justify their prediction. Then, they observe the phenomena. Finally, they explain any conflict between their prediction and observation.
Ruiz-Primo and Furtak (2006) argue, first, that the more complete the cycle, the more likely it becomes that the information gathered will be used in helpful ways for learning purposes. Second, the quality of informal assessment practices can also be determined by diverse types of questions and statements used by the teachers. Diana’s lessons showed the highest percentage of complete cycles, followed by Carol, Adam, and Ray. Incomplete ESR cycles were found most frequently in Carol’s lessons in the form of temperature taking.

Diana asked scientific explanations, repeated or re-voiced students’ contributions, elaborated on the comments, and gave evaluative responses. The evaluative responses were used in tandem with other recognizing or using strategies. Carol used the most diverse strategies across all the ESRU cycles. She responded to a student’s contribution by asking another student to repeat it, thus making a key idea more explicit in the discussion. She frequently provided students with additional information to help them move forward in their thinking. Adam asked multiple questions without rephrasing. He did not exhibit effective formative assessment when leading a discussion. He did not seem to recognize what the student had said, but asked the same question again with little change. Ray asked questions and repeated students’ words with minimal instructional intervention. He accepted all comments at face value and then called on the next student. He was completely neutral to student contributions, and followed students’ comments without intervention.

In summary, Carol and Diana conducted more assessment conversation than Adam or Ray. In particular, Carol emphasized concepts and took action on information collected across multiple cycles. The researchers linked the levels of teachers’ informal
assessment practices with the levels of student performance. Students’ learning was measured with multiple choice, short answer, performance assessment, and predict-observe-explain, in pre- and post-test design. On average, students were similar in their understanding level of relative density before the implementation of investigation, and students’ performance at the beginning was not associated with teacher. Evidence suggested that the students’ performance was consistent with the levels of the quality of the informal assessment practice. Carol’s and Diana’s students consistently showed higher performance than Adam’s and Ray’s.

**Classroom Discourse Literature**

The classroom discourse literature is important to note since the current focus in formative assessment is on the nature of classroom interactions between the teacher and the students. For example, Hoetker and Ahlbrand (1969) reviewed studies from the 1890s to 1960s of sequences of teacher-student interaction patterns. They found that teachers talked two-thirds of the class time; teachers were responsible for initiating and responding to questions that called for short factual answers from students; and students’ main task was to produce short answers to teacher’s solicitations. This pattern remained unchanged for several decades. Later, Sirotnik (1983) documented empirically the pedagogical trend such as classroom interaction patterns up to the 1980s. The documentation substantiates the findings of Hoetker and Ahlbrand (1969). The classroom interaction patterns could be described as teachers explaining, lecturing, or asking factual questions, while students are listening to the teacher or responding to teacher-initiated interaction. This line of inquiry is important, because improving teaching and learning requires knowing what is happening in the classrooms.
From these observations, a teaching sequence was derived that was persistent in classroom instruction: teacher’s question, student’s response, and teacher’s reaction to that response. This is called “recitation script” (Hoetker & Ahlbrand, 1969, p. 149), where teachers solicit factual answers from textbook material. Mehan (1979) and Cazden (2001) called this tripartite structure of teacher initiation – student response – teacher evaluation/feedback, or IRE/F sequence. In this tripartite, IRE/F sequence, teacher talk dominated the discussion. Later, formative assessment researchers and teacher questioning researchers took up this structure to analyze classroom instruction and observed alternative forms of teaching sequences such as extended sequences (Chen, Crockett, Namikawa, Zilimu, & Lee, 2012; Crockett, Chen, Namikawa, & Zilimu, 2009; Mehan, 1979), ESRU cycles (Ruiz-Primo & Furtak, 2006, 2007), IRFRF (Chin, 2006), and RFR (van Zee & Minstrell, 1997).

Hoetker and Ahlbrand (1969) further stimulated researchers to investigate this teaching sequence of pedagogical moves and to devise methods to increase the effectiveness of teacher’s solicitations and reactions. They observed that teachers posed large numbers of questions without allowing enough wait-time for students to formulate their ideas to answer any questions. This teacher domination of classroom talk indicates that teachers are doing most of the work, and little effort is put into foster students’ independent thinking. Because talk, spoken out loud, results in learning on the part of the speaker, it is reasonable to argue that more time must be allotted for student talk to foster student thinking.

The link between social interaction and students’ development of mathematical thinking was examined by Wood, Williams, and McNeal (2006). They noted differences
between conventional and reform-oriented classes, and among reform-oriented classes, in terms of social features and the quality of students’ thinking. They examined the relationship between interaction patterns and students’ verbalized mathematical thinking within classroom cultures. They classified categories of classroom cultures as four: “conventional, conventional problem-solving, strategy reporting, and inquiry/argument” (p. 225). The former two are observed in conventional classes, while the latter two are observed in reform-oriented classes. In strategy-reporting classes, students present different strategies used for solving a problem. In the inquiry/argument classes, students not only offer different solution methods, but also provide reasons for their thinking so that it makes sense to others. The conceptual framework considered two dimensions, student participation and student mathematical thinking.

In conventional classes such as conventional textbook and conventional problem-solving classes, interaction patterns such as the following were observed: “IRE, give expected information, funnel pattern, and hint to solution” (pp. 233-234). In IRE, a teacher initiates a question, a student responds, and the teacher evaluates student’s answer. With give expected information, students provided taught information. With funnel pattern, the teacher led students to a correct answer through a series of questions. With hints to solution and IRE, the teacher dominated the class discussion, and there was little opportunity for students to express their own mathematical thinking.

In reform-oriented classes such as strategy reporting and inquiry/argument classes, interaction patterns such as the following were observed: “exploring methods, teacher elaboration, argument/inquiry, building and checking for consensus” (p. 235). In exploring methods, students presented to others their strategies for solving problems.
With teacher elaboration, teachers elaborated on and extended students’ explanations to make sure that the important ideas were conveyed to the other students. Argument/inquiry involves students participating in challenge and justification. Building and checking for consensus involves teacher and students participating to establish shared or common meaning for mathematical ideas.

Whereas in the conventional textbook class the lesson involved students’ mathematical thinking only at the level of recognition of taught information, in conventional problem-solving class students expressed thinking that was at higher levels such as application and analysis. In strategy-reporting classes, there was a shift in emphasis from recall of taught information to comprehension, application, and analysis, without, however, any student contribution with mathematical thinking. In inquiry/argument classes, students participated more in interaction patterns involving clarification, justification, and validation of their mathematical understanding and expressed higher levels of mathematical thinking than in strategy-reporting classes.

Wood et al. (2006) argued that social interaction patterns established in the classroom affect how students construct mathematical knowledge in the classroom. They showed that the interaction patterns that required greater involvement from the participants were related to higher levels of expressed mathematical thinking. On the other hand, Nathan and Knuth (2003) found that interaction pattern alone does not guarantee improvement in the quality of students' thinking. In their effort to conduct an action research of a sixth-grade teacher’s math classroom during two-year period, they discovered that even though student interaction among themselves increased significantly during the second-year intervention, a lack of rigorous mathematical argumentation was
evident. There is room for teachers to acknowledge the pedagogy related to classroom
discourse in the teaching of mathematics.

**Pedagogy Related to Classroom Discourse in Math**

In their review of research, Walshaw and Anthony (2008) investigated features of
effective pedagogy that are specific to classroom discourse in math classrooms. They
raised the question: “What are the characteristics of pedagogical approaches to classroom
discourse that produce desirable outcomes for diverse students?” (p. 518). They searched
for empirical research that made direct links between pedagogy and student outcomes,
both academic and social. They identified four themes that are germane to their research
question: “(a) participating rights and obligations, (b) differentiating between responses
and supporting students’ thinking, (c) fine-tuning mathematical thinking through
language, and (d) shaping mathematical argumentation” (p. 522).

The first level, “participating rights and obligations” (p. 523), involves teachers
“setting up the social norms for classroom interaction” (p. 523). They set classroom
norms concerning “when and how to contribute to mathematical discussions, and what to
do as a listener” (p. 523). However, “a pedagogical approach that can move students’
thinking forward involves much more than creating a safe climate for discussion” (p. 527)
and acceptance of other students’ differing ideas at face value. In the second level,
teachers “differentiate between responses and support students’ thinking” (p. 526).

Teachers synthesize students’ contribution and differentiate between the
mathematical integrity of students’ ideas; They orchestrate mathematical
discourse through careful questioning and purposeful interventions; They
intervene to redirect discussion to ensure that important mathematical ideas are being developed. (pp. 526-528)

The focus moves from student talk, per se, to the content of student talk.

In the third level, “fine-tuning mathematical thinking through language” (p. 532), teachers connect students’ informal representations to formal mathematical language. They create environments so that students can “appropriate the mathematical language of the wider mathematical community” (pp. 532-533). However, “mathematical language involves more than technical vocabulary. It encompasses how it is used within mathematical argumentation” (p. 535). In the fourth level, teachers guide students to use mathematical language to “shape mathematical argumentation” (p. 535). Students are encouraged to “prove their ideas, as well as critique others’ ideas” (p. 535). Teacher questions, comments, and feedback involved in these processes move classroom conversation in mathematically productive ways.

**Questioning and Feedback**

Gall (1970) reviewed research on spoken questions that occur during classroom discussion and distinguished between teachers’ questions emphasizing students’ critical thinking and recall of facts. From the review of research, she found that two-thirds of teacher questions called for recall of facts, and this instructional practice remained unchanged after decades. Gall speculated a few reasons for the focus on recall of facts for so many years. First, although higher-level questions should be encouraged, teachers need to check students with fact questions for them to be able to explore more thought questions. Second, Gall hypothesized that teachers’ use of fact or higher-level questions is dependent on the curriculum available to them. In other words, if traditional curriculum
is available to the teachers, it is more likely that they will ask fact questions. In contrast, if they use reform curriculum, it is highly likely that teachers will ask questions that incorporate critical thinking and problem solving. Third, the lack of effective teacher-training programs might explain why instruction has focused on recall of facts instead of the asking of questions at higher levels of cognition.

Gall (1970) further suggested considering whether there are effective question sequences and researching follow-up questions. She hypothesized that the follow-up questioning of the student’s initial response will have significant impact on student learning. The issue of follow-up questioning of the student’s initial responses was taken up by researchers who study teacher questioning (Chin, 2006) and those who study teacher feedback (Tunstall & Gipps, 1996). In her questioning-based analytical framework, Chin (2006) described four possible actions that a teacher could take based on his/her interpretation of the correctness/accurateness/completeness of students’ responses. In a similar way, Tunstall and Gipps (1996) developed a typology of teacher feedback by identifying achievement feedback and improvement feedback, both of which are associated with formative assessment practices.

Feedback can take the form of questions and statements made to students to improve their learning. It is defined as “information provided by a teacher, a peer, or self, regarding aspects of one’s performance or understanding” (Hattie & Timperley, 2007, p. 81). Feedback fills a gap between what is understood and what is aimed to be understood. It can be accepted, modified, or rejected. Hattie and Timperley identified conditions that maximize the positive effects of feedback on learning. The main purpose of feedback is “to reduce the gap between current understanding or performance and the desired goal”
(p. 86). To reduce the discrepancy between current and desired understanding, students can “increase effort, develop self-regulation strategies, and seek better strategies” (p. 86). Teachers can provide challenging and specific goals.

**Professional Development Programs**

In my pilot study, the teachers indicated that in their professional development experience there was a focus on formative assessment. Therefore there are several things to consider about professional development in South Korea in this regard. First, teacher professional development is mandatory in South Korea. If the teachers are learning about formative assessment, professional development is the most likely source. The U.S. literature indicates that teacher learning is essential to successful implementation of reform movements (Grant, Peterson, & Shojgreen-Downer, 1996; Penuel, Fishman, Yamaguchi, & Gallagher, 2007). What are the structures and contents of the professional development experiences that teachers have? How do these experiences influence their instruction?

After reviewing various professional development programs that foster formative classroom assessment, Schneider and Randel (2010) discovered several characteristics of effective formative classroom assessment professional development programs. First, for professional development in formative assessment to be effective, the teachers need “support from the school and district administrators” (p. 262). Second, the learning goals for teachers of the professional development are not prescribed for all the participating teachers, so that individual teachers can pursue their own inquiries during their participation in the program (p. 263). Third, a successful professional development program focuses on “increasing teachers’ knowledge of how to teach a specific content
and how students learn the subject matter (i.e., pedagogical content knowledge), rather than merely increasing teachers’ knowledge of the subject matter (i.e., subject-matter knowledge)” (p. 263). These include “strategies and methods for designing sound assessments, collecting information of student learning, and communicating the learning expectation to the students” (p. 263). Fourth, teachers need sufficient time to “acquire knowledge of the principles of formative assessment” and to “integrate newly acquired strategies by practicing them in their daily instruction” (p. 264). Fifth, collaboration within professional learning communities should be developed to “share ideas, observe one another’s classrooms, and incorporate reflections to improve their own practices” (p. 265). Sixth, the ideas touted in professional development programs must be “in alignment with what already exists in the schools, such as their previous professional development programs, teachers’ expertise, curricula, and state standards” (p. 265). Seventh, teachers need “hands-on experience of formative assessment practice rather than mere increased knowledge of principles” (p. 266).

**Pedagogical Content Knowledge**

Shulman’s (1986) notion of teachers’ professional knowledge base, whereby pedagogical content knowledge is one knowledge base, can serve as a framework for considering professional development programs (Borko & Putnam, 1995). Pedagogical content knowledge (PCK) is subject-matter knowledge for teaching. It is “the way of representing and formulating the subject that make it comprehensible to students such as through analogies, illustrations, examples, explanations, and demonstrations” (Shulman, 1986, p. 9). Shulman first introduced PCK to educational research, and it has seen further development for subject disciplines such as history, English, math, and science (Falk,
In Shulman’s (1986) notion, teachers’ professional knowledge base consists of general pedagogical knowledge, subject-matter knowledge, and pedagogical content knowledge. These three components can serve as a framework (Borko & Putnam, 1995) for considering professional development programs.

First, general pedagogical knowledge consists of “learning environment/instructional strategies, classroom management, and knowledge of the learning process” (Borko & Putnam, 1995, pp. 39-42). In the cognitive-mediational conception, learning occurs when students act upon new information and relate it to existing knowledge by reorganizing or even restructuring the existing knowledge base. In the receptive-accrual view, in contrast, students’ role is to receive information presented by the teacher and practice the skills without necessarily making an effort to integrate it to his/her own knowledge structure. Reform educators take the former approach, the cognitive-mediational conception, to teaching and learning. The teacher’s role is that of a mediator of learning rather than of a provider of information. Students are seen as actively engaged in constructing knowledge rather than passively receiving disconnected information. Teachers prepare academic tasks that require higher levels of student thinking (e.g., making connections among interrelated concepts, justifying, explaining, and arguing), not just recall or reproduction of predetermined short answers. Teachers assess students’ progress of learning with various assessment strategies before, during, or after instruction. It is the teacher’s role to create a supportive learning environment.

Second, subject-matter knowledge includes “knowledge of the content of a discipline, as well as the substantive and syntactic structures of the discipline” (Borko & Putnam, 1995, pp. 43-46). When teachers attempt to practice problem-based instruction
or use real-world contexts to enhance student thinking, the teachers’ subject-matter knowledge becomes even more crucial. Teachers need to acquire an understanding of the nature of mathematical knowledge, that it is a domain of human inquiry that is subject to debate, and not just a simple collection of facts and procedures imposed by external authorities such as mathematicians.

Third, pedagogical content knowledge is “an understanding of how a subject area, and the topics and issues within it, can be organized and represented for teaching” (Borko & Putnam, 1995, p. 46). It consists of “knowledge of instructional strategies and representations, knowledge of students’ understanding and potential misunderstandings, and knowledge of curriculum and curricular materials” (pp. 47-51). Teachers should develop extensive repertoires of powerful representations such as “models, examples, metaphors, simulations, demonstrations, or illustrations” for teaching concepts. For instance, in teaching two-digit multiplication, a teacher can introduce an area model to enhance conceptual understanding. Teachers should be aware of the topics students frequently find difficult and have strategies for addressing those difficulties. Teachers should have in-depth knowledge about the organization and structure of curriculum within different subjects of a grade level and across K-12 curriculum.

**Professional Development Programs about Formative Assessment**

Even though PCK is deemed important in teachers’ teaching and their professional learning, little empirical study examines the way PCK contributes to formative assessment practices, or vice versa. Falk (2011) investigated the reciprocal relationship between PCK and formative assessment in a science professional development program in which eleven fourth-grade teachers were involved. He examined
“how PCK acted as a resource for formative assessment, as well as how formative assessment created opportunities to build PCK” (p. 266). He conceptualized PCK as having five components, “orientation to the teaching and learning of science, knowledge of curriculum, knowledge of assessment, knowledge of students’ understanding, and knowledge of instructional strategies” (p. 268-269), and pursued the question: “How do teachers use and build different components of PCK as they engage in collaborative formative assessment practices?” (p. 270).

The professional development program was held once a week for eight weeks, each session lasting for three hours. The first half of each session was devoted to reviewing and discussing students’ written work samples with a focus on assessment. The second half of each session was devoted to discussing the topics related to electricity and electric circuits with a focus on science content. The findings suggest that PCK was an integral part of teachers’ formative assessment practices, even though particular components of PCK were prominent, such as knowledge of curriculum, knowledge of instructional strategies, and knowledge of student understanding. Conversely, formative assessment was instrumental in building different components of PCK, although particular types of PCK were built through formative assessment, including knowledge of student understanding, knowledge of curriculum, and limited amount of knowledge of assessment. They have in common two elements, and one different.

Frey and Fisher (2009) ran a four-year professional development program focused on elementary-school teachers’ formative assessment practices of their students’ writing performance. Data were collected during “teacher meetings, professional development sessions, semi-structured interviews, and classroom observations” (p. 674). The
professional development sessions were held bi-weekly for four hours a month, where teachers spent focused time developing a writing curriculum based on their review of students’ written work through collaboration and consensus building.

In the first cycle, teachers met to agree on curriculum guides that specified which “content standards, core vocabulary, instructional materials, and instructional strategies” (Frey & Fisher, 2009, p. 675) they wished to focus on for their instruction. During the second cycle, teachers developed common formative assessment items consisting of ten to twelve questions and a writing task for their students. The formative assessment items were based on the standards and the curriculum guides that the teachers had previously agreed upon. The third cycle focused on analyzing students’ performance and using the results to inform following instruction.

The professional development program run by Frey and Fisher (2009) resulted in significant learning gains in student achievement in overall language-arts study including reading and writing. For example, the numbers of students who read at grade level increased, and the Academic Performance Index (API), which is a student score on an accountability test, increased significantly. It is noteworthy that this professional development program was not a one-shot experience where educational researchers instructed teachers about effective instructional strategies. Instead, the participating teachers met bi-weekly in a four-year program to agree on curriculum guides, to create formative assessment tasks, to analyze students’ performance, and to discuss how to adjust their instruction to move students forward. This evidence suggests that the answer for improving student achievement lies with “local teachers who can understand and
implement formative assessment and align instruction with the assessments” rather than in “state testing or commercial programs” (Frey & Fisher, 2009, p. 679).

Thompson and Wiliam (2008) ran a professional development program, called Keeping Learning on Track (KLT), to encourage teachers to adopt formative assessment practices and strategies in their classrooms. The program consisted of two phases: (a) introducing teachers to the key ideas of assessment for learning, and (b) engaging teachers in school-based teacher learning communities. In the first phase, the teachers were introduced to basic information about the concept of assessment for learning. This included the five practices of assessment for learning, samples of teaching strategies related to each of the five strategies so that teachers can select and customize in their own classrooms, and introduction to the nature of the teacher learning communities. During the second phase, the teachers had opportunities for practice in their own classroom settings followed by reflections on the teacher learning communities.

The Keeping Learning on Track professional development program mirrors a three-step process (Leusner, Ellsworth, & Goe, 2008):

(a) Teachers learn extensively about assessment for learning through workshops and sustained engagement in teacher learning communities; (b) teachers adopt a better approach to teaching, implementing formative assessment practices through classroom techniques; (c) student learning is improved because of the improvement in teaching. (p. 106)

The idea is that teachers learn formative assessment practices and strategies through sustained professional development programs, and that teachers’ improvement in teaching leads to the improvement in student learning.
In their case studies of KLT implementation, Leusner, Ellsworth, and Goe (2008) learned that,

Although there can be variations depending on the local contexts, the content and the process of the program must be focused on the core content of formative assessment practices; that the practitioners need to lead teacher learning communities because the leaders need to understand what happens in the classroom teaching; and that the teacher learning communities must meet regularly. (p. 121)

Whereas many professional development programs are one-shot, the most effective professional development programs must be sustained over time to support teachers.

The literature described here will inform the analysis described in the next chapter.
Chapter 3

Methods

Research Questions

The primary research question is: What are Korean middle- and high-school math teachers’ understandings of formative assessment? More specifically, what are the formative assessment practices that the teachers identify, and what formative assessment strategies do they use before, during, and after teaching? Second, what are the policy contexts in which teachers do their work? More specifically, how do Korean math teachers feel that current education policy (social, political, and educational) impacts their formative assessment practices? Third, how do the teachers come to learn about formative assessment practices? More specifically, what role does professional development play in both learning and implementation? What is the role of lesson planning and other learning opportunities in teachers’ implementation of formative assessment?

Theory/Rationale for an Interview Study

I conducted an interview study as opposed to a survey or ethnographic study. Survey research takes the forms of “face-to-face interviews, self-administered questionnaires, telephone interviews, and online interviews” (Bernard, 2011, p. 187). The survey method allows a researcher to gather data from a large, representative sample of respondents. In face-to-face interviews, the researcher can probe for more complete data if the respondent is not answering fully. The disadvantage is that it can be reactive. In other words, it can be difficult to administer an interview without subtly telling the respondent how the researcher hopes the respondent will answer. With self-administered
questionnaires, there is no concern about interview bias or response effects, based on features of the interviewer. It allows more complex and sensitive questions, because anonymity provides a sense of security. The disadvantage is that the researcher has no control over how people interpret questions on the questionnaire. Questionnaire and survey research requires a large sample of respondents, and the data are aggregated to find results, yet this does not serve my purposes.

A semi-structured, or in-depth interview is open ended, letting respondents express themselves in their own terms and at their own pace, but it does follow an interview guide. An interview guide is a written list of questions and topics that need to be covered in particular order. It demonstrates that a researcher is fully in control of what he/she wants from an interview, but leaves both the researcher and the respondents to follow new leads. In comparison to an unstructured interview characterized by a minimum control over the people’s responses, a semi-structured interview allows the researcher to maintain discretion to direct the discussion and to make sure important topics are addressed.

An ethnographic study provides a rich description of a culture. It requires a participant observation research method, which Bernard (2011) explains:

It opens up and makes it possible to collect all kinds of data; It reduces the problem of reactivity of people changing their behavior when they know that they are being studied; It helps to ask sensible questions in the native language; It gives an intuitive understanding of what is going on in a culture and allows to speak with confidence about the meaning of the data. (pp. 265-266)
Engaging in long-term participant observation would mean extensive immersion in the Korean classroom culture that I am studying. While culture is important, I am interested in gathering information in face-to-face, semi-structured interviews, because the teachers’ responses about their own understandings of formative assessment practices can be starting points for the design of large-scale survey studies and questions for ethnographers to explore in long-term engagements with teachers in classrooms. The results of this study may also address a gap in policy studies in Korean education that may need to be filled.

An interview is a structured conversation whose purpose is to construct knowledge through the interaction of the interviewer and interviewee. It is different from everyday conversation because it involves “questioning and listening approach with the purpose of obtaining thoroughly tested knowledge” (Kvale, 1996, p. 6). There are two approaches for a research interview study: “a miner metaphor and a traveler metaphor” (pp. 3-4). The miner metaphor is influenced by the positivistic conception of social sciences as natural sciences, whereas the traveler metaphor is influenced by the interpretivist approach, where new conceptions of knowledge construction in social science are promoted. I was inclined to take on the traveler metaphor, where the stories of participants were differentiated and reconstructed through my own interpretation and analysis, and remolded into new narratives for an external audience. The transition from miner approach of interviewing to the traveler approach emphasizes the constructive nature of knowledge.
Analytic Approach

The approach used in this study is informed by the theorization of formative assessment formulated by Stiggins (2010) and Black and Wiliam (2009). My research questions are listed below:

1. **What are Korean middle- and high-school math teachers’ understandings of formative assessment?**
   - What are the formative assessment practices that the teachers identify?
   - What formative assessment strategies do they use before, during, and after teaching?

2. **What are the policy contexts in which teachers do their work?**
   - How do Korean math teachers feel that current education policy (social, political, and educational) impacts their formative assessment practices?

3. **How do the teachers come to learn about formative assessment practices?**
   - What role does professional development play in their learning and implementation?
   - What are the roles of lesson planning and of other learning opportunities in teachers’ implementation of formative assessment?

To answer the first research question about teachers’ formative assessment practices, I formulated interview questions for the first semi-structured interview. To triangulate data collected in the first semi-structured interview about teachers’ implementation of formative assessment practices and strategies, I administered the fifth semi-structured interview, and explored teachers’ formative assessment practices, more specifically, their DAP practices. To answer the second research question about the
impact of educational policy in teachers’ practice, I formulated interview questions for the second semi-structured interview. In addition, I conducted a document review of data for local contexts and policy documents for the second research question. To answer the third research question about teachers’ learning opportunities, I formulated interview questions for the third and fourth semi-structured interviews. I collected and reviewed lesson plans and teacher handbooks to answer the third research question.

**Limitations**

The limitations of the study include, for example, interviewer bias, which is always a concern. I tried to mitigate the bias by first engaging in “prolonged engagement” (Lincoln & Guba, 1995, p. 301), an investment of sufficient time to build trust. I invested time, before conducting five semi-structured interviews, for an informal contact meeting with each individual teacher to introduce myself and explain briefly the proposed study. The semi-structured interviews consisted of five meetings taking thirty minutes for each interview. This should be sufficient time for building trust, and taking into account any distortions that might creep into the data.

Second, I used “triangulation” to improve the probability that the findings and interpretations are credible (Lincoln & Guba, 1995, p. 305). For example, in the first semi-structured interview, I asked teachers questions about their understandings and their actual implementation of formative assessment practices. However, what teachers say and what they are able to do can be different. The fifth semi-structured interview serves a very important purpose by gathering data from teachers that could help me triangulate data across previous interviews.
In the fifth interview, I examined a student’s written mathematical work and asked teachers how they would collect evidence of student learning, interpret student understanding as well as misunderstanding, and use the evidence to make adjustments to their instruction. In addition, I asked teachers to analyze students’ written responses, rank strategies according to their sophistication, and explain reasons to support the rankings. This helped me see any inconsistencies between what the teachers say and do. Finally, I asked teachers to review two classroom scenarios that represent convergent and divergent formative assessments, and to think about similarities and differences in each scenario. Through this activity, what teacher beliefs are about traditional and reform approaches to teaching and learning, and how they would characterize their own practice, could be explored.

In addition, informal classroom observations were used to explore any possible differences between what teachers say and do. I asked teachers if they were willing to invite me to one of their classrooms for an informal classroom observation. I took notes while observing the lesson, but did not record the lesson in any forms (i.e., no audio/video). The notes taken during the observation focused on teachers’ instructional practice with regard to formative assessment. Three teachers (Teacher Shim, Teacher Koh, and Teacher Hwang) generously invited me to one of their classrooms in the middle of November, 2014. Because the time was close to winter vacation and many teachers had already completed covering the curriculum for the semester, I could not make classroom observations of other teachers. Through the classroom observations, I got a general sense of how the class starts and ends, and what classroom activities students were engaged during instruction. Classroom observations were conducted at a public
middle school (Teacher Shim), a public high school (Teacher Koh), and a public special-purpose high school (Teacher Hwang).

Finally, I wrote “reflexive journal, a kind of diary in which the investigator, on a daily basis, records a variety of information about self and method” (Lincoln & Guba, 1995, p. 327). It consisted of

(a) the daily schedule and logistics of the study; (b) a personal diary that provides opportunities for reflection about growing insights; and (c) a methodological log in which methodological decisions and accompanying rationales are recorded. (p. 327)

On the left-hand side of a notebook, I wrote the date and listed the agenda for a given day, and on the right I listed what I have done (Bernard, 2011).

Participants and Settings

Participants in the study. Seven middle school teachers and five high school teachers were included in the study. All teachers had educational background in math education or math. Their teaching experiences ranged from 4 years to 31 years.

Background to teacher preparation programs. To become a math teacher in a secondary school in Korea, one must pursue an undergraduate degree in mathematics education in the department of education at an accredited four-year university. Alternatively one can pursue an undergraduate degree in mathematics and minor or double-major in education. There are three major areas of study when majoring in mathematics education: mathematics content courses, pedagogy courses, and pedagogy in mathematics education courses. Upon graduation, one obtains a teaching certificate, which meets the minimum requirement to become a teacher in private and public schools.
To work in public schools, however, one must get a passing score on the “national teacher employment test” (Kim, Ham, & Paine, 2011, p. 51), which is one kind of civil service examination and has become highly competitive.

The following is a sample of undergraduate courses that a teacher candidate in Korea takes as coursework, which can be categorized broadly in three areas: mathematics content courses, education courses, and mathematics education courses. First, mathematics content courses include Calculus I, Calculus II, Logic and Set Theory, Linear Algebra I, Linear Algebra II, Advanced Calculus I (Real Analysis I), Advanced Calculus II (Real Analysis II), Complex Analysis, Probability Education for Secondary School Teachers, Statistics for Secondary School Teachers, Topology, Abstract Algebra, Algebra for Secondary School Teachers (Abstract Algebra II), Introduction to Differential Geometry, Number Systems and Coding Theory, and Problem Solving in Discrete Mathematics. Second, education courses include Introduction to Education, Philosophy and History of Education, Educational Psychology, Educational Administration and Management, Curriculum and Instruction, and Educational Evaluation. Third, mathematics education courses include Educational Methods and Technology, Materials Development and Teaching Methods in Mathematics (developing lesson planning), Computers in Secondary Mathematics, Teaching Practicum (student teaching experience), and Theoretical Foundations of Teaching Mathematics Education.

**Selection of participants.** For the recruitment of participants, I contacted a principal and a university professor to ask for referrals for math teachers in the community who might be interested in the study. After contact information for prospective participants (e-mail, school, phone number) was received, each was
telephoned and e-mailed for invitation to the study. The e-mail invitation to the study is included in the appendix (see Appendix A). The recruitment e-mail asked for mathematics teachers who have at least one year of full-time teaching in the middle or high school, who are currently employed as mathematics teachers, and who have adequate time to participate in five thirty-minute semi-structured interviews (Spradley, 1979). I was responsible for contacting subjects for interviews, mainly through telephone calls and e-mails, and for arranging times for these interviews.

Recruitment efforts reflected an attempt to develop a sample that included both male and female teachers; both public and private schools; both middle- and high-schools as sites; teachers with diverse ranges of years (from 1 year to 20-plus) of teaching experience; and teachers’ educational background in mathematics or mathematics education. First, both male and female teachers were included. Second, both middle and high schools were included as research sites. Both public and private schools were included. For instance, seven middle-school math teachers from both public and private schools were selected. Five high-school math teachers from two general high schools, two independent private high schools, and a special-purpose high school were selected. Third, teachers with a wide range of years of teaching experience (ranging from 4 years to 31 years of teaching experience) were included. In particular, I recruited participants who have at least a year of full-time involvement in middle- or high-school as a math teacher. Fourth, teachers who have a minimum of bachelor’s degree in either math or math education were recruited. See Table 2 for the profile of the participants.
Table 2

Profile of the Participants

<table>
<thead>
<tr>
<th>Gender</th>
<th>Name of the School</th>
<th>Undergraduate Major</th>
<th>Graduate Major</th>
<th>Years of Teaching Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Middle School</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Ahn</td>
<td>F</td>
<td>Middle School 1</td>
<td>Math Education</td>
<td>Math Education</td>
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<tr>
<td>Teacher Yang</td>
<td>F</td>
<td>Middle School 2</td>
<td>Math Education</td>
<td>Math Education</td>
</tr>
<tr>
<td>Teacher Kang</td>
<td>F</td>
<td>Middle School 3</td>
<td>Math Education</td>
<td>Math Education (Algebra)</td>
</tr>
<tr>
<td>Teacher Shim</td>
<td>F</td>
<td>Middle School 4</td>
<td>Math Education</td>
<td>-</td>
</tr>
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<td>Teacher Jeon</td>
<td>F</td>
<td>Middle School 5</td>
<td>Math Education</td>
<td>Math Education</td>
</tr>
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<td>Math Education</td>
<td>Math Education</td>
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<td>Math Education</td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>Math Education (Algebra)</td>
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<tr>
<td>Teacher Hwang</td>
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<tr>
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</tr>
<tr>
<td>Teacher Choi</td>
<td>M</td>
<td>High School 5</td>
<td>Math Education</td>
<td>Math Education</td>
</tr>
</tbody>
</table>

**Informal meetings with participants.** Twelve teachers agreed to participate after I telephoned and e-mailed them to invite them to the study. I asked all twelve for informal meetings at their convenience. All teachers additionally agreed to participate in the informal meeting. During December 2012 (before I took the preliminary examination) and November 2013 (after I took preliminary examination), I made the informal “contact visit” (Seidman, 2006) with all of the teachers individually according to their availability.
at that time. I met with each of them for about half an hour to introduce my study and myself. The purpose of the contact visit is multi-fold (Seidman, 2006):

1. to lay the ground of the mutual respect necessary to the interview process and explain the nature of the interview study;
2. to determine whether potential participants are interested;
3. to initiate the process of informed consent; and
4. to assess the appropriateness of a participant for the study, that is, to determine whether the subject of the researcher’s study is central to the participant’s experience. (pp. 46-48)

During the informal meeting, I explained the following: (1) the research topic and research questions, that I am trying to study Korean middle- and high-school math teachers’ understandings of formative assessment; (2) the nature of this study, that it is a qualitative study implementing in-depth interviews; (3) my background information as a researcher, that I have been pursuing research on formative assessment and classroom discourse in mathematics teaching and learning for my doctoral study, and how I became committed to investigating the current research subject; and (4) the timeline for my study.

Then, I briefly explained the structure of the five semi-structured interviews, the topics to be discussed in each interview, and what would be expected of the subjects. For example, the first and second interviews cover general questions about formative assessment practices. The third and fourth interviews will expand on the teachers’ answers from the previous interviews and include supplemental questions that arise. The fifth interview will examine students’ written work from a published article and will seek responses to teachers’ discourse-based formative assessment practices.
Finally, I briefly explained the informed consent process and explained that I would need to get institutional review board’s (IRB) approval and pass my preliminary examination to be able to conduct my research. The teachers’ concerns were addressed.

**Research sites.** Seven middle schools and five high schools are included in the study. The schools are located in a capital city and three other smaller cities in a Southwestern Province. The capital city has a population of 650 thousand as of 2014. In terms of education, the province administers high school entrance examination, targeting students in their third year of middle school. The score of high school entrance examination counts up to 180 points, and the score of students’ report cards counts up to 70 points. These scores are combined (180+70 = 250) so that decisions on entering high schools can be made. Other vocational high schools only take into account the students’ academic report cards. It is important to note that the high school entrance examination is unique in this province. Other provinces abolished the high school entrance examination in the past.

**Background to the types of high schools.** Beginning in the 1990s and encouraged during 2000s, the Korean government adopted reform policies for the diversification of the high-school system to reduce the bureaucratic control of the centralized education system and instead increase the market’s control by offering administrative autonomy and flexibility in the public education system (Oh, 2011). It focused on transforming public education into a marketized and privatized system. The reform movement began with the dissatisfaction with the equalized public school system that was brought about as a result of the High School Equalization Policy (HSEP) imposed in 1978 (Lee, Lee, & Jang, 2010).
The high-school diversification policy generated two strategies: school specialization and privatization (Oh, 2011). In accordance with school specialization, there are special-purpose high schools exclusively focusing on science and math, foreign language, and arts, and with privatization, independent private high schools. The independent private high schools are classified within the parameters of general high school, but they are different from conventional high schools because they are influenced by market forces and are guaranteed school autonomy in student selection, finances, and personnel. Currently, there are four main types of high schools: “general high schools, independent private high schools, special-purpose high schools, and specialized vocational high schools” (p. 385). Among the types of high schools, the special-purpose science/math and foreign-language high schools and the independent private high schools are the most prestigious. These schools are fewer than the number of general high schools, although many students aspire to enter them.

Types of schools included in this study. Seven middle schools and five high schools are included in this study. Of the middle schools, five are public school and two private. All middle schools in this study are mixed schools in terms of the gender of the students, except one, which is all-male middle school. For high schools, three are public and two private. Among them, one is a special-purpose high school, focusing on science and math, and two are independent private high schools. Two are all-male school and one all-female school. Table 3 indicates the type of middle and high schools, the number of classes that participants were teaching in the Year 2013, and the number of students per classroom.
### Table 3

*Profile of the schools and classrooms participants were teaching in the school year 2013*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Name of the School</th>
<th>Type of School (Public/Private)</th>
<th>Type of School (Gender of the Students)</th>
<th>Number of Classes Teaching in School Year 2013</th>
<th>Number of Students per Classroom (Male/Female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Middle School 1</td>
<td>Public</td>
<td>Mixed</td>
<td>5 classes</td>
<td>38 (19M/19F)</td>
</tr>
<tr>
<td>F</td>
<td>Middle School 2</td>
<td>Public</td>
<td>Mixed</td>
<td>18 classes</td>
<td>36 (20M/16F)</td>
</tr>
<tr>
<td>F</td>
<td>Middle School 3</td>
<td>Public</td>
<td>Mixed</td>
<td>5 classes</td>
<td>40 (22M/18F)</td>
</tr>
<tr>
<td>F</td>
<td>Middle School 4</td>
<td>Public</td>
<td>Mixed</td>
<td>21 classes</td>
<td>33 (18M/15F)</td>
</tr>
<tr>
<td>F</td>
<td>Middle School 5</td>
<td>Public</td>
<td>Mixed</td>
<td>5 classes</td>
<td>38 (20M/18F)</td>
</tr>
<tr>
<td>F</td>
<td>Middle School 6</td>
<td>Private</td>
<td>Male</td>
<td>5 classes</td>
<td>25 (25M/0F)</td>
</tr>
<tr>
<td>F</td>
<td>Middle School 7</td>
<td>Private</td>
<td>Mixed</td>
<td>4 classes</td>
<td>28-38</td>
</tr>
<tr>
<td>F</td>
<td>High School 1</td>
<td>Public</td>
<td>Male</td>
<td>4 classes</td>
<td>28 (28M/0F)</td>
</tr>
<tr>
<td>F</td>
<td>High School 2</td>
<td>Public</td>
<td>Female</td>
<td>3 classes</td>
<td>38 (0M/38F)</td>
</tr>
<tr>
<td>M</td>
<td>High School 3</td>
<td>Public Special-purpose high school</td>
<td>Mixed</td>
<td>3 classes</td>
<td>21 (17M/4F)</td>
</tr>
<tr>
<td>M</td>
<td>High School 4</td>
<td>Independent Private high school</td>
<td>Male</td>
<td>6 classes</td>
<td>38 (38M/0F)</td>
</tr>
<tr>
<td>M</td>
<td>High School 5</td>
<td>Independent private high school</td>
<td>Mixed</td>
<td>4 classes</td>
<td>30 (20M/10F)</td>
</tr>
</tbody>
</table>

### Data Collection

I audio recorded each interview with the consent of the teachers and created transcriptions of the digitally-recorded interviews. During the interviews, I took jottings and later turned them into field notes. The jottings and the field notes that were taken during and after the fieldwork were the primary data for the analysis stage. I made three
informal classroom observations. I took notes while observing the lesson, but did not record the lesson in any forms (i.e., no audio/video). In addition, I asked the teachers for and gathered teacher handbooks and their lesson plans for document review. While in South Korea for fieldwork, I also collected data for local contexts and policy documents for future review. For example, the Korean Ministry of Education (MOE) website (http://www.mest.go.kr/main.do) provides demographic information on teachers and students in primary, secondary, and tertiary education, educational statistics, and educational policy documents. The Korea Institute for Curriculum and Evaluation (KICE) website (http://www.kice.re.kr/index.do) provides various research reports about curriculum and evaluation. In summary, the following data were collected:

- Audio recordings of the interviews
- Transcriptions of digitally-taped interviews
- Field notes of interviews and classroom observations
- Teacher handbooks
- Lesson plans
- Data for local contexts and policy documents

Table 4 lists the research questions and the applicable data sources; Table 5 lists the dates and times I met with teacher participants for contact visits and five interviews, and dates and times I visited their classroom for classroom observation, and; Table 6 shows timeline for data collection and analysis.
Table 4

*Research Questions and Data Sources*

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are Korean middle- and high-school math teachers’ understandings of formative assessment? - What are the formative assessment practices that the teachers identify? - What formative assessment strategies do they use before, during, and after teaching?</td>
<td>First semi-structured interview Triangulate in the fifth semi-structured interview</td>
</tr>
<tr>
<td>2. What are the policy contexts in which teachers do their work? - How do Korean math teachers feel that current education policy (social, political, and educational) impacts their formative assessment practices?</td>
<td>Second semi-structured interview Document review: data for local contexts and policy documents</td>
</tr>
<tr>
<td>3. How do the teachers come to learn about formative assessment practices? - What role does professional development play in their learning and implementation? - What is the role of lesson planning and other learning opportunities in teachers’ implementation of formative assessment?</td>
<td>Third and fourth semi-structured interview Document review: lesson plans, teacher handbooks</td>
</tr>
</tbody>
</table>

To answer the first research question about teachers’ formative assessment practices, I formulated interview questions for the first semi-structured interview. To triangulate data collected in the first semi-structured interview about teachers’ implementation of formative assessment practices and strategies, I administered the fifth semi-structured interview, and explored teachers’ formative assessment practices, more specifically, their DAP practices. To answer the second research question about the impact of educational policy in teachers’ practice, I formulated interview questions for the second semi-structured interview. In addition, I conducted a document review of data for local contexts and policy documents for the second research question. To answer the
third research question about teachers’ learning opportunities, I formulated interview questions for the third and fourth semi-structured interviews. I collected and reviewed lesson plans and teacher handbooks to answer the third research question.

Table 5

Dates and Times for Contact Visit, Five Interviews, and Classroom Observations

<table>
<thead>
<tr>
<th></th>
<th>Middle School</th>
<th>Contact Visit</th>
<th>First interview</th>
<th>Second interview</th>
<th>Third interview</th>
<th>Fourth interview</th>
<th>Fifth interview</th>
<th>Classroom Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Teacher Yang</td>
<td>12/19/2013</td>
<td>12/23/2013</td>
<td>12/23/2013</td>
<td>12/30/2013</td>
<td>12/30/2013</td>
<td>12/31/2013</td>
<td>6:00pm</td>
</tr>
<tr>
<td>3</td>
<td>Teacher Kang</td>
<td>11/18/2013</td>
<td>11/28/2013</td>
<td>12/19/2013</td>
<td>12/19/2013</td>
<td>12/26/2013</td>
<td>12/31/2013</td>
<td>6:00pm</td>
</tr>
<tr>
<td>5</td>
<td>Teacher Jeon</td>
<td>12/18/2013</td>
<td>12/20/2013</td>
<td>12/24/2013</td>
<td>12/26/2013</td>
<td>12/30/2013</td>
<td>12/30/2013</td>
<td>6:00pm</td>
</tr>
<tr>
<td></td>
<td>High School</td>
<td>Contact Visit</td>
<td>First interview</td>
<td>Second interview</td>
<td>Third interview</td>
<td>Fourth interview</td>
<td>Fifth interview</td>
<td>Classroom Observation</td>
</tr>
<tr>
<td>4</td>
<td>Teacher Yoon</td>
<td>11/8/2013</td>
<td>11/18/2013</td>
<td>11/18/2013</td>
<td>12/2/2013</td>
<td>12/2/2013</td>
<td>12/20/2013</td>
<td>6:00pm</td>
</tr>
<tr>
<td>5</td>
<td>Teacher Choi</td>
<td>11/12/2013</td>
<td>11/20/2013</td>
<td>11/26/2013</td>
<td>11/28/2013</td>
<td>12/2/2013</td>
<td>12/19/2013</td>
<td>6:00pm</td>
</tr>
</tbody>
</table>

The contact visits were made with each teacher participants before conducting interviews. Five, thirty-minute semi-structured interviews were conducted with twelve teachers during November – December in 2013. Three classroom observations were also made during November 2013. I transcribed the interviews in Korean throughout November, December in 2013 and January 2014. The data were analyzed in Korean.
throughout the data collection process and afterwards. The first draft of my dissertation was written during January – March, 2014, and was revised during March – May, 2014.

Table 6

*Timeline for Data Collection and Analysis*

<table>
<thead>
<tr>
<th></th>
<th>Fall 2013</th>
<th>Spring 2014</th>
<th>Summer 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant Confirmation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule Interviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conduct Interviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transcription</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing Paper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Examination</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Jottings.** Transcription is only one part of data collection and cannot be the sole method. I captured the participants’ meanings by following up on their prior responses or statements and by recording what I learned. The audio-recordings, transcriptions, jottings, and field notes constitute the major data collection method and were combined to generate meaningful findings.

There are two modes of participation: “experiential” and “participating-to-write” modes (Emerson, Fretz, & Shaw, 1995, pp. 17-19). In the experiential mode, the researcher immerses him/herself deeply into the activities of participants, and postpones writing notes until the end of the day, when he/she leaves the field. In the participating-
to-write mode, the researcher begins taking notes while he/she is still in the field to capture the spoken dialogue and actions of the participants. In my study, rapid switching between the two modes was necessary. The experiential mode was used sparingly when I visited each participant’s workplace (i.e., their school site for interviews and their own math classrooms for classroom observations) from time to time upon their invitation, and any time when I sensed that “taking out a note pad and writing jottings would ruin the moment” (p. 20). During the five semi-structured interviews, I took notes with the consent of the teachers. Although the interviews were supposed to be audio-recorded and be transcribed later, hand-written jottings still remained useful when I tried to “reconstruct the memories” into full-blown field notes at the end of the day. After each interview, I turned jottings into field notes.

Field notes. After returning from each interview, I described the participant, place, and interview conversations, creating descriptive field notes (Bogdan & Biklen, 2007, pp. 120-121). I did portraits of the participant to include details such as their affiliation. I reconstructed the dialogue using quotations to enhance the approximation of what was said. I described the physical setting where the interview took place. In addition, I recorded ideas, concerns, reflections, hunches, and noted patterns that emerged. These constituted reflective field notes (pp. 122-124). With reflective field notes, I reflected on analysis by “speculating about what I am learning, what I am going to do next, and what the outcome of the study is going to be” (p. 122). I found themes and patterns that emerged, and made connections among data sets (p. 123). I reflected on the method by being aware of the procedures and strategies and of the evolution of the study’s design (p. 123). I also reflected on the ethical dilemmas that arose during the study. The reflective
field notes took forms of observer’s comment (O.C.) when it was shorter and memos when it was longer. The observer’s comments and memos were scattered throughout the notes.

**Data Analysis**

In his book on interview studies, Weiss (1994) introduces ways to analyze interview data. There are two modes of analysis: issue-focused and case-focused. While a case-focused analysis is concerned with putting together the materials of an individual case, an issue-focused analysis is concerned about learning specific issues from all participants. I conducted an issue-focused analysis, because it would increase my ability to answer my research questions in particular ways. There are three analytic processes that I was involved in an issue-focused analysis: “sorting, local integration, and inclusive integration” (p. 154).

**Sorting.** I made second copies of interview transcripts and field notes, sorted them in topical units, and saved them in file folders labeled with the titles of the chapter sections. These constituted excerpted files, which would be interpreted in the local integration stage. First, in the local integration, the excerpted material of the file folders would be interpreted with mini-theories. During the inclusive integration, the collection of file folders would be organized into a coherent structure (p. 157).

**Local integration.** Local integration means finding a way of organizing and integrating the observations and understandings in each section of the report (p. 158). To achieve local integration, I started by summarizing the excerpted file. I restated or quoted what participants said about a topic and interpreted its meaning and implications. If there
were materials that deviated from the main line of thought, I explained why cases that do not follow the main line are different.

From the beginning of the study, I developed “mini-theories,” working hypotheses whose aim was to make sense of material dealing with specific issues. I found excerpted materials to corroborate the mini-theories. While one mini-theory offered a basis for the integration of some areas, it did not do so for other areas. In those instances, I developed other mini-theories. To corroborate the mini-theories, I included excerpted files, interview material that has not been used, and searched for relevant literature.

**Inclusive integration.** While local integration brought coherence and meaning to excerpted file materials, inclusive integration created a single coherent story that included the otherwise isolated areas of analysis that resulted from local integration (p. 160). I developed a framework that included all the analysis I wanted to report, moved logically from one area to the next, and led to a general conclusion.

**Procedures**

The informal contact visits, the structure and contents of the five semi-structured interviews, and informal classroom observations are described in this section.

**Informal contact visits.** Before the five semi-structured interviews, I contacted participants directly and invited them to participate in an “informal interview” (Bernard, 2011) at a time and location convenient to them. This took twenty to thirty minutes. The time was used for introductions, explanation of the objectives of the study, description of procedures (e.g., the length of each interview, the content of the interview), and to address the participants' questions regarding the study.
**Five semi-structured interviews.** After the informal contact with the participants, I conducted five semi-structured interviews with each teacher. Before the interview, a consent form was introduced and explained. Individual interviews took place face-to-face and were tape-recorded (audio). Each interview was from three days to a week apart (Seidman, 2006). This allowed time for me to transcribe and interpret what has been discussed previously and to think through what contingent topic to pursue in the next interview, but not enough time to forget what has been discussed previously and lose connection between the two interviews. The spacing also allowed me to work with an individual teacher over a three- to four-week period.

During the first and second interviews, the time was devoted to discussing general questions about formative assessment practices. Some questions that were asked include the following: teachers’ own definitions of formative assessment, examples of formative assessment practices and strategies they use in their own classrooms, the process of the implementation of formative assessment strategies, the challenges of implementing formative assessment strategies (if any), and the impact of educational policy on their formative assessment practices.

The third and fourth interviews expanded on the teachers' answers from the previous interviews, and supplemental questions that arose were asked. I followed up on any issues that might have transpired during the previous interviews. Moreover, I asked about teachers’ learning opportunities about formative assessment such as professional development programs and workshops; the structure and contents of the professional development and workshop experiences, and their impact on teachers’ instruction. I also asked about their lesson plans, and how the formative assessment component is prepared.
in the lesson planning. Korean teachers attend professional development programs and workshops regularly on summer and winter vacations. They also write lesson plans as a common practice to be submitted to the principal before the academic year starts.

The fifth interview sought responses to teachers’ discourse-based formative assessment practices. It served an important purpose because the data that I gathered from the teachers could help me triangulate the data across previous interview responses. The literature review provided me with a background for examining three mathematical tasks with the teachers during the fifth semi-structured interview.

In the first activity, a two-digit multiplication problem was selected. This type of problem fosters student understanding of how a number is composed, the concept of place value, the meaning and rationale of multiplication, the distributive law, and the commutative law (Ma, 1999, p. 45). The second activity was selected from a unit on fractions and ratios. This type of problem fosters student understanding of the concept of unit and part-whole relationships, and introduces the concept of fractions and ratios. This can lead to operations involving fractions such as division by fractions. These two activities were selected because multi-digit multiplications and fractions and ratios are fundamental to algebraic understanding and can be a stepping stone into studying algebra, which is a “gatekeeping subject” for entering college (Moses & Cobb, 2001). In the third activity, two classroom scenarios, where the teacher and students are working on a law of exponents, were provided. Teacher participants were asked to review the scenarios and asked to think about similarities and differences in each scenario. The scenarios represent convergent and divergent approaches of teaching and learning. This activity explores
teachers’ understanding of discourse-based formative assessment practices (DAP). (See Appendix B for the details of the three activities.)

First, I introduced a two-digit multiplication problem and showed how a fictitious student solved the problem. Then, I asked teachers several questions to examine how they would interpret student understanding and misconceptions. For example, I asked,

(a) What is the correct answer? (b) What type of problem is this? (c) What are the strengths and weaknesses of the student’s work? (d) What are the mathematical concepts and ideas at play in this problem? (Crockett, 2012)

I also asked several questions to examine how the teachers would use the evidence of student learning to inform their next instructional moves. For instance, I asked,

(a) What instructional strategies would you employ so that the student can solve the problem with understanding? (b) If you were to use manipulatives, which would you use, how would you use them and why? (c) What questions would you ask to ensure mathematical understanding prior to, during, and after teaching? (d) What feedback would you provide to this student? (Crockett, 2012)

The interview questions encompass all three core components of DAP, eliciting and gathering evidence of student learning, interpreting student understandings and misunderstandings, and using the evidence of student learning to inform instruction in a timely manner.

Second, I examined students’ written work with the teachers and explored questions posed by Lamon (1999). I chose one task from Lamon to be used in the fifth semi-structured interview. It is about part-and-whole relationship of fractions (p. 75). In the book, it was placed between a chapter about units and unitizing (p. 39) and a chapter
on partitioning and quotients (p. 75). The task is attached in Appendix B. It introduces mathematical problems given to students and captures students’ written work. I asked the teachers to “analyze students’ written responses to see if their strategies are correct, and rank the strategies according to their sophistication, explaining reasons to support the rankings” (p. 75). This interview question is very important because empirical research suggests that while teachers do better at drawing inferences of student levels of understanding, they have difficulty making use of the assessment information and deciding the next instructional steps (Heritage, Kim, Vendlinski, & Herman, 2009). This part of the interview served another very important purpose by gathering data from teachers that could help me triangulate data across previous interviews.

Third, I introduced two classroom scenarios where the teacher and students are working on exponents. The scenarios were adapted from Lampert (1990). The first scenario represents convergent formative assessment, while the second represents divergent. Teachers were asked to review the scenarios and to think about similarities and differences in each scenario. Teachers’ overall impressions, opinions about two approaches to teaching, and how they would teach differently were investigated. Through this activity, what teacher beliefs are about traditional and reform approaches to teaching and learning, and how they would characterize their own practice could be explored.

Informal classroom observations. Informal classroom observations were used to triangulate any possible difference between what teachers say and do. I asked teachers if they were willing to invite me to one of their classes for an informal classroom observation. I took notes while observing the lesson but did not record the lesson in any forms (i.e., no audio/video). The notes taken during the observation was focused on
teachers’ instructional practice with regard to formative assessment. Three teachers generously invited me to one of their classrooms in the middle of November, 2014. Because the time was close to winter vacation and many teachers had already completed the curriculum for the semester, I could not make classroom observations of other teachers. Through the classroom observations, I got a general sense of how class starts and ends, and what classroom activities students were engaged during instruction. Classroom observations were conducted at a public middle school, a public high school, and a public special-purpose high school.

I visited Teacher Shim’s Year 3 public middle school classroom on November 26, 2013 from 2:15pm to 3:00pm (45 minutes). The lesson was about the proportional relationship between the tangent and secant lines to a circle. At the beginning of the lesson, the teacher asked questions to students about the terminology, tangent and secant lines, to recall from previous lessons. She also asked questions at brisk pace about the condition of similarities between two triangles to capture students’ understandings. The teacher demonstrated a proof about the proportional relationship between two secant lines to a circle when the lines met inside or outside the circle. She explained how to solve two example problems and then had students solve exercise problems. She circulated around the class to observe students’ written work on their notebooks, and appointed several students to present their strategy on the board and explain. The class ended with teachers’ announcement of next lesson.

I observed Teacher Koh’s public high school classroom on November 15, 2013 from 11:10am to 12:00pm (50 minutes). The lesson was held in a lab classroom for math, equipped with smartboard facility. The lesson was using definite integrals and
fundamental theorem of calculus to solve problems. The teacher explained various concepts on the smartboard gauging student understanding by asking questions occasionally. She then allowed some time for students to solve similar problems on their own, distributed formative-assessment worksheet consisting of three problems to solve, and circulated around the class to provide extra help. At the end of the class, the teacher announced for next class and assigned homework.

I visited Teacher Hwang’s special-purpose high school classroom on November 13, 2013 from 1:45pm to 3:00pm. The lesson was about preparing students for indepth interview for prestigious universities. There were three male students. The teacher explained various theorems and proofs at high-school level as well as at the college level, including topics in elliptic equations and number theory.

I have to admit that the number of classroom observation was too small. However, from these classroom observations, I learned that teachers’ instruction and their formative assessment practices ranged widely. Teacher Shim’s instruction was more convergent and traditional, as she also expressed in the fifth interview that she feels it necessary to explain concepts upfront as a teacher. Teacher Koh’s instruction somewhat deviated from the traditional approach. I could understand how educational policy (such as supporting lab classrooms) can have impact on teachers’ daily instruction and their formative assessment practices, and enable teachers to incorporate more reformed approach in math instruction.

In summary, the study relied on, but was not limited to, in-depth interviews with semi-structured questions. The interviews were conducted in Korean. Interviews lasted approximately thirty minutes, according to the teachers' availabilities, and they were tape-
recorded with the consent of the teachers. The interviews were conducted at a time and location convenient to the participants (e.g., cafes, offices, or at public libraries). Answers were then analyzed based on the content. I first transcribed all the interviews in Korean, analyzed data in Korean, and then translated selected portions into English for the final report.
Chapter 4

Korean Middle- and High-School Math Teachers’ Understanding of Formative Assessment

Following Duncan and Noonan’s (2007) recommendations for studying the practices of formative assessment, my dissertation study included a sample of both middle and high school teachers, seven middle school teachers and five high school teachers. Whereas Duncan and Noonan provide a list of assessment practices through a survey questionnaire from a large number of teachers (n = 513), my dissertation study describes in detail the formative assessment practices and strategies that teachers employ by conducting in-depth interviews with twelve teachers. Korean teachers described in full what their assessment practices entailed and explained the role of their assessment practices, as opposed to merely listing their practices. Following the approach of other researchers (Black & Wiliam, 1998, 2009; Duncan & Noonan, 2007; Erickson, 2007; Stiggins, 2010; Webb, 2004), I analyzed teachers’ formative assessment practices as occurring in three stages: gathering evidence of student learning, interpreting evidence gathered, and using the information to adjust instruction.

It is significant to note that Korean teachers were able to distinguish between formative and summative assessments. I started with teachers’ own definition of summative assessment, teachers’ own definition of formative assessment, and teachers’ general description of classroom practice, and then I moved to more specific examples of formative assessment practice, which serve as evidence of their understandings. The specific examples of formative assessment practices are grouped into three large categories: eliciting evidence of student learning, interpreting evidence gathered of
student learning, and making adjustments to subsequent instruction (Black & Wiliam, 1998, 2009; Duncan & Noonan, 2007; Erickson, 2007; Stiggins, 2010; Webb, 2004).

Finally, I investigated obstacles to implementing formative assessment.

**Teachers’ Own Definition of Summative Assessment**

At the basic level, summative assessment is described as an overall evaluation of students’ academic achievement. It is used to evaluate how many of the learning objectives have been met at the end of a major instructional period, such as a chapter or a semester. Two teachers (Teacher Jeon and Teacher Kang) made reference to the learning objectives when defining summative assessment. Teacher Jeon said that it is “a tool to judge how far along students have arrived at the learning objectives in the long run.” Teacher Kang said that it is “an overall evaluation of whether learning objectives have been met.” Additionally, Teacher Seo stated that it is “a finish line of learning.”

Five teachers (Teacher Shim, Teacher Yoon, Teacher Ryu, Teacher Choi, Teacher Ahn) emphasized the stage at which the summative assessment is administered. Teachers conduct summative assessment in the final stage of major instructional period, such as when a chapter is completed or when a semester is over. Teacher Ryu and Teacher Yoon wanted to check if an overall understanding of the entire chapter had been achieved, before students take school’s regular exams, such as mid-terms or final examinations. When a whole chapter is done, teachers want to evaluate how much of the contents – definitions, theorems, proofs, key concepts, problems – have been acquired by their students. For example, Teacher Shim said, “When a whole chapter is done, there are learning objectives of the chapter, including various definitions, key concepts, contents of
the lesson, and application problems. Summative assessment is checking overall how much students have acquired of these.”

Four teachers (Teacher Yang, Teacher Koh, Teacher Cho, Teacher Hwang) stressed an important aspect of summative assessment, that it is used to keep detailed records of students’ academic progress. Summative assessment can be directly related to grades that are calculated for students’ academic report cards, which are later used when students enter high schools or colleges and universities. Teacher Cho best expressed this process as:

Summative assessment is to keep records – numeric and verbal records. If I am a Year 1 middle school student, it is to leave records of my achievements in math in the academic year in numeric numbers. And it will have a huge impact on students. Yes, huge impact on students. Because it will be left there in students’ academic report cards, which will be used when they enter high schools.

In this case, the summative assessment leaves both numeric and verbal data of the students’ math achievement. Both teachers and students take it very seriously.

Examples of summative assessment are schools’ regular exams, such as mid-term and final exams, which are administered bi-monthly, when two or two-and-a-half chapters are done (Teacher Seo, Teacher Yang, Teacher Cho, and Teacher Hwang). For the paper-based assessment, most schools administer the first exam (previously called the “mid-term exam”) and the second exam (previously called the “final exam”). In one independent private high school, three examinations were administered within a semester. The first exam and the third exam were similar to the mid-term and final exams, respectively. The second exam was a 100% long-descriptive-answer assessment
The performance assessment is administered throughout the academic year and is used, along with the paper-based assessment, in calculating the student academic report cards. It is administered frequently during the instruction, and is focused on checking student preparation for, attitudes about, and participation in the class.

When a chapter is completed, teachers (Teacher Ryu, Teacher Ahn, Teacher Yoon, Teacher Kang, Teacher Shim, and Teacher Jeon) prepared paper-based assessments on their own, following a format similar to mid-terms or final exams. The purpose of this practice is to help students prepare themselves to take the school’s regular exams. For example, Teacher Shim described the content of the paper-based assessment as consisting of “(a) the review of problems in the textbook or exercise book, (b) a selection of good-quality problems that have been addressed before in class, and (c) additional new problems such as real-life examples.” She has students solve twenty problems of the above items in a 45- or 50-minute class period, grades them, and addresses any questions students might have after returning them to students.

Uniquely among this group, Teacher Choi prepared quizzes for grading purposes for every chapter. The scores are reflected on the performance assessment. Each quiz consists of four to five long-descriptive-answer problems that require detailed description of solution strategies. The purpose of administering these problems is to check students’ understanding of the overall contents of the chapter. He grades the quizzes, makes the scores public, goes through an appeal process when students have different opinions, and convinces students of their initial or revised scores. The process is a bit of hassle, he said, because they are long-answer problems, which are difficult to grade, and it can be difficult to convince students of their scores. Through this process, he is preparing
students for the school’s regular exams, since the percentage of long-descriptive-answer questions in mid-term and final exams is increasing every year.

Another form of summative assessment, defined by the teachers, is a mock-test administered by the Province’s Office of Education or by external private organizations. The mock-test is used to prepare students for their high school entrance examination for middle school students, or college entrance examination for high school students. According to Teacher Koh, Year 1 and Year 2 high school students take the mock-test four times a year, while Year 3 students take it once a month. The frequency of administering mock-tests is very different from one province to another. However, the province under study does not recommend administering mock-tests too frequently. Instead, they increased the number of mock-tests administered by the Province’s Office of Education from two times a year to four times a year, while trying to eliminate mock-tests administered by private organizations.

**Somewhere Between Summative and Formative Assessments**

When teachers were asked what comes to their mind when they hear the word “assessment,” some teachers (Teacher Ahn and Teacher Choi) instantly thought of tests, exams, and student academic report cards. They also understood that assessment would be burdensome for students. For some other teachers (Teacher Hwang, Teacher Cho, Teacher Yoon, Teacher Yang, and Teacher Shim), assessment is used to judge the level of student academic achievement by ascertaining how much students have understood the lesson content. In Teacher Cho’s words, assessment is used to check “how much students have learned, have acquired in their mind, and have come to know the content.” Some teachers (Teacher Ryu, Teacher Kang, Teacher Koh, and Teacher Jeon) report using
assessment results as a reference to improve curriculum material and their methods of instruction. Through assessment, teachers come to know where students lack understanding. This process is essential because they have to guide students in the proper direction.

In general, the teachers indicated that assessment is part of the learning process. The teachers emphasized that both students and teachers need assessment. An assessment can turn out to be a learning experience for students in that they can use the result to improve their academic achievement. Teachers can use assessment results to give feedback and guide students, as well as to adjust their own lessons. However, several teachers express concern about assessment from the students’ perspective. First, they feel that assessment raises anxiety or dread. Students, they think, might feel that they are being evaluated and are being placed in a rank order against a pool of their peers. Students might feel that they are being tested to see whether or not they have learned and understood a lesson’s content. Teacher Koh’s sentiment best describes both teachers’ and students’ perspectives:

From a teacher’s point of view, assessment seems to me a method to check the levels of students’ academic achievements. It feels more like a tool to gauge or check the levels of students’ understandings. But for students, from students’ perspectives, I think they feel burdensome. They might feel that they are being ‘checked’ by their teachers on what they have learned and understood, so it can be heavy on them. However, there are parts where they can learn to improve through the whole process, maybe get stimulated or motivated by it. The whole process is necessary for students. I feel that assessment is an inevitable process.
Three other teachers (Teacher Ryu, Teacher Kang, and Teacher Jeon) said that assessment is used to help improve their instruction. Teacher Kang said,

When I was a student, I felt that I was being evaluated. Now as a teacher, I think assessment is a tool to improve curriculum and instruction and its purpose is not to rank students’ order. Rather, through assessment I want to improve the methods of my instruction. I use assessment as a reference to guide my instruction.

In a similar way, Teacher Ryu said,

It is to check how much students know. It feels heavy on students. However, I have to check how much students understand, check their levels of understanding, and use the results to help my students improve their work. So it is necessary.

I asked the following two questions in anticipation that the first question will generate answers closer to evaluation methods and that the second question would pull answers closer to formative assessment methods: (1) How do you assess your students’ math performance, and (2) how do you check whether your students have learned what you have taught? As it turned out, only three teachers (25%) explicitly listed summative assessment through the school’s regular exams (e.g., paper-based assessment and performance assessment mandated by the school) for the first question. Most other teachers explained assessment practices conducted for formative purpose in both questions.

**Teachers’ Own Definition of Formative Assessment**

At the basic level, formative assessment is used to check how much students have followed the teacher’s instruction, to check how much students have achieved, and to see how well they are comprehending instruction within 45-50 minutes class period. One
high school teacher (Teacher Seo) and two middle school teachers (Teacher Jeon and Teacher Yang) defined formative assessment in the way just described. Teacher Seo best represented this: “It is checking how much students have followed my instruction, and checking on the spot how well they are doing. It is a stepping stone for the next step.”

Second, formative assessment is used to check the level of student achievement with regard to the learning objectives, and to check the level of student understanding with respect to the content of the lesson, at the beginning, in the middle, and at the end of instruction. Teachers have, in their minds, the learning objectives and instructional content to teach within the 45-50 minute period. They constantly ask themselves: “Have my students achieved the learning goals? Have they mastered the instructional content?”

Seven teachers (Teacher Koh, Teacher Hwang, Teacher Cho, Teacher Ahn, Teacher Kang, Teacher Yoon, Teacher Shim) defined formative assessment with reference to either learning objectives or instructional content. Among them, two teachers (Teacher Koh and Teacher Hwang) made reference to both learning objectives and instructional content. Three teachers (Teacher Cho, Teacher Ahn, and Teacher Kang) addressed only instructional content, and two teachers (Teacher Yoon and Teacher Shim) addressed only learning objectives. According to Teacher Hwang, formative assessment is “a tool to judge how much students have mastered the instructional content (curricular material) discussed during the class period, and how far they have achieved the learning goals.” Moreover, according to Teacher Koh, formative assessment is used “to check how much students have understood and to what extent they are able to apply their knowledge to solve problems.”
Third, formative assessment provides helpful information for both teachers and students. It enables teachers to provide feedback to students about where they lack understanding and how they can improve their work. Teacher Koh went on to say, “Formative assessment is not an end itself. Its purpose is to provide feedback. Through the feedback, teachers let students know where they are lacking understanding so that students realize their strengths and weaknesses and can act upon it.” It provides direction for teachers regarding how to improvise during an ongoing lesson, or how to plan their instruction for future classes. Teacher Cho said,

Teachers cannot assume that students will know everything and become only focused on covering the materials in time. There has to be some checking on the students, on how they are doing, and based on that observation I can get directions for the next step, or guidance on how I can proceed with the next instructional move.

For example, when Teacher Ryu observes that students are lacking understanding in a certain area, she plans how she would teach differently in the next lesson. If most students seem to understand, she reckons that she can go on to the next part of her instruction.

Finally, two teachers (Teacher Ryu and Teacher Choi) said that formative assessment “forms” the knowledge structure about the chapter. It is a process that helps student understanding and guides teachers in their next lesson by checking where students are in their learning progression. Teacher Ryu said,

Formative assessment is an assessment that is in the process of the ‘formation,’ in my opinion. If students are learning a chapter, it is the intermediate steps of
developing full understanding about the chapter. Students have to understand this step to be able to move on to the next step. So formative assessment is helping students with their understanding and helping me check on students’ levels of understanding and providing directions for my next instruction.

Examples of formative assessment can be categorized into four types. First, teacher questioning and solicitation of student answers can occur at the beginning of the lesson, during the lesson, or at the end of the lesson. Second, teachers examine written and oral presentation of student work. While a student presenter writes his or her solution process on the board, other students are engaged in writing their own strategies on their notebooks. Teachers can walk around to review the written forms of students. After the student presents, discussion among students can arise, and teacher questioning and provision of feedback follow. Third, some teachers administer tests and quizzes and provide homework assignments, formative-assessment worksheets, or a set of long-descriptive-answer questions. Fourth, small group activities, bingo games, and math journaling are used in math classrooms. Detailed description of each item is given in the later section: Teachers’ Formative Assessment Practices and Strategies.

**General Description of Classroom Practice**

The formative assessment practices under investigation in this interview study occur in middle and high school mathematics classrooms. The teachers’ interview data indicate that classrooms routines are remarkably similar, which I confirmed through three formal classroom observations. Math classes last 45 minutes in middle schools and 50 minutes in high schools. During the first 5-10 minutes, the teacher takes attendance. After making sure everyone is seated, the teacher reminds the class of what they learned in the
previous lesson. The teacher reviews material from the previous lesson by asking questions and soliciting answers from students. Some teachers check homework assignments. Then the teacher introduces the topic for the day’s lesson. To get students’ attention and to induce motivation for learning, the teacher sometimes brings examples from real life that are related to the lesson.

The teachers indicated that during the middle 30-35 minutes they use two-thirds of the time introducing and explaining definitions, theorems, and proofs. When explaining key concepts, they sometimes engage students to answer the question, “What should we do in this step?” Then they introduce a couple of key example problems and demonstrate how to solve them. Using the remaining one-third of the time in the middle period, they have students work on related problems, letting them discuss with one another. As the teachers explained, they walk around the class to make sure everyone is on task and to provide help when necessary. Typically, they select some students to come to the board in front of the class, have them write their solution process on the board, and have them explain to the whole class.

During the last 5-7 minutes of the classroom routine, the teachers indicated that they summarize what’s been covered during the lesson and announce assignments for the next class.

**Teachers’ Formative Assessment Practices and Strategies**

Within this typical routine, the teachers are engaged in formative assessment practices. According to Black and Wiliam (1998, 2009) and Stiggins (2010), effective formative assessment strategies include (a) creating high-quality assessment tasks before instruction, (b) eliciting evidence of student learning, (c) interpreting elicited evidence of
student learning, (d) communicating assessment results to students during instruction, and (e) making adjustments to subsequent instruction, after instruction. By analyzing the data, I found rich information about Korean teachers’ formative assessment strategies around three broad practices of eliciting evidence of student learning, interpreting elicited evidence of student learning, and making adjustments to subsequent instruction.

In each of these three practices, I found several strategies. First, I found four specific examples of strategies designed to elicit evidence of student learning: (a) questioning and soliciting answers, (b) written and oral presentation of strategies, (c) use of tests and quizzes, and (d) small group activities. Second, teachers interpret gathered evidence of student learning by tending to students’ verbal and written expressions. Verbal expressions include (a) student responses from teacher solicitation/elicitation, (b) discussion among students, and (c) student questions to their teacher. Written forms include solution strategies written on the board or on students’ individual notebooks. Third, teachers make adjustments to subsequent instruction by using assessment information they gathered. The assessment information can be interpreted in two ways: (a) information that is derived from observations of students at work during instruction, and (b) information that is derived from assessing students’ work in paper-based examinations. Table 7 summarizes broad practices described in the formative assessment literature and matches them with Korean teachers’ formative assessment strategies that are more specific.
### Table 7

**Teachers’ Formative Assessment Practices and Strategies**

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<th>Formative Assessment Practices Described in the Literature Review</th>
<th>Korean Teachers’ Formative Assessment Strategies</th>
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<td><strong>Before Instruction</strong></td>
<td>(a) Create high-quality assessment tasks</td>
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<td><strong>During Instruction</strong></td>
<td>(b) Elicit evidence of student learning</td>
<td>- Questioning and soliciting answers</td>
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<td>- Written and oral presentations</td>
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<td>- Use of quizzes and tests</td>
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<td>(c) Interpret elicited evidence of student learning</td>
<td>- Students’ verbal expressions</td>
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<td>- Students’ written expressions</td>
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<td>(d) Communicate assessment results to students</td>
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<tr>
<td><strong>After Instruction</strong></td>
<td>(e) Make adjustments to subsequent instruction</td>
<td>- Using assessment information from observation of students at work during daily instruction</td>
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<td>- Using assessment information from paper-based assessments</td>
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**Eliciting Evidence of Student Learning**

**Questioning and soliciting answers.** The first strategy in eliciting evidence of student learning is teacher questioning and soliciting student answers. Questioning and soliciting answers can happen at the beginning of a lesson while reviewing previous lesson content. It can also happen at the end of a lesson where the teacher checks whether students have learned what he or she has taught. For example, Teacher Kang asks a lot of
questions during instruction not to explain, but to check to what extent students have acquired what has been taught. She said,

I ask lot of questions during instruction. The format of the lesson follows the sequence of explaining the lesson content, solving problems, and listening to student presentations. Throughout the process, I throw out questions to check whether students have understood. I ask questions to the whole class and sometimes to an individual student.

Teacher Shim asks similar questions to a number of students at a brisk pace when teaching definitions, such as, for instance, definitions of sine, cosine, and tangent.

During the lesson, Teacher Koh sometimes asks questions of an individual student or of the whole class to convey an important lesson. Teacher Koh explained, “There are parts where the whole group can learn by listening to the teacher talking to an individual student.” She uses questioning strategy for two purposes: (a) to give opportunities for students to discover something important on their own, and (b) to emphasize an important concept. In Teacher Koh’s own words,

When students are not able to catch things that I want them to discover, I intentionally ask what is meant in this part. If a student is able to discover, the other students also can realize what they weren’t able to identify before. I ask questions to the whole class if there is an important formula that I expect everyone to remember. This time the question is intended to emphasize, so that students can perceive the importance of the content.

Other teachers take seriously any student questions about the homework assignments. It can tell whether students are struggling with the basic concepts or with the applications.
**Written and oral presentations.** The second strategy in eliciting evidence of student learning is examining students’ written and oral presentations. Teachers explained that they examine students’ written work and observe oral presentations of student solution strategies. For example, Teacher Koh stated that she demonstrates how to solve a couple of example problems (예제). Then, she provides time for students to solve similar problems (유제) and exercises (연습문제). While students are writing their strategies and solutions in their notebooks, the teacher walks around the class to check students’ written work in the notebook or in the margins of the textbook, and to provide help. Several students are selected to come in front of the class and present their work on the board. The teacher observes what’s written on the board, and asks the students to explain the process. By observing the written representation and listening to the oral presentation, the teacher makes sure that the students can express their thoughts verbally besides being able to solve the problem.

In a similar way, Teacher Hwang uses a projector for student presentations so that students’ attention can be drawn to the front of the class. A student’s solution process is shown on the projector, and a student explanation follows. When the classroom does not have this equipment, the student presenters come to the front and write down their strategies on the board, while other students write their own strategies on their notebooks. Teacher Jeon adds on to the process that the student presenters receive points that are later added to their performance assessment item. Other students get the teacher’s signature on their notebook, which will later be reflected on their performance assessment category.
Teacher questioning and solicitation of student answers are integrated into the student presentation process. For instance, Teacher Ahn has students present their work on the board and asks them to explain their strategies. Teacher Ahn said, “Through student explanation, I gather a lot of information that could not be gained by only looking at the result of regular exams, which are mostly multiple-choice items or short-answer questions. I come to know where students produce errors frequently.” She intentionally asks the presenter several additional questions to gauge the levels of students’ understandings as a whole group. By observing the rest of the students who are listening to their peer’s explanation, she also can gauge their levels of understanding as a whole group. In Teacher Ahn’s own words,

The question, which I pose to the student presenter, is intended to be heard by other students, too. When I see the class, I find some students who catch what I am conveying through the question and find other students who do not know what I am asking. So, there I can differentiate the levels of students’ understanding. In other words, through the process of questioning and soliciting student answers, she can differentiate students who are following well from those who are having difficulty by looking at their facial expressions.

The presentation of student strategies is sometimes followed by discussion among students along with teacher questioning and provision of feedback. In Teacher Jeon and Teacher Ryu’s classrooms, students are sometimes invited to ask questions, or to point out some parts that would result in errors, after listening to the presenter’s explanation of his or her solution strategy. Any student can elaborate upon the error, explain how it can be fixed, or suggest a better strategy. These teachers (Teacher Jeon and Teacher Ryu) ask
if anyone has different strategies, invite them to share various methods with the class members, and foster discussion among the students. In particular, Teacher Ryu acknowledged, “When students raise questions with one another, it is not merely that particular student’s own wonderings, but it gives an opportunity for other students to take a second look.” When a student presenter seems to explain without firm conceptual understanding, teachers correct the misunderstanding. Teachers can take a good grasp of students’ levels of understanding by looking at the solution process written on the board, by hearing the student’s explanation, and by asking additional questions.

The teachers balance the level of participation so that everyone has an opportunity to be engaged in the discussion, not merely a few active or talkative students. Teacher Koh wants all students to feel that they themselves are the assessors. When asked to explain further what is meant by students becoming the assessors themselves, Teacher Koh explained,

If a student is designated to be the speaker, what happens is that only that student is involved in the process. So I intentionally ask questions of the whole class or try to call on students who are less active or students who appear to participate less, so that no one is left out and everyone can participate. Moreover, if there are students who are passive, Teacher Jeon has students write a set of questions that arise during the lesson and submit the list to the teacher at the end of instruction. This way, she gets to know where students are having difficulty. She writes some comments for each question that students have posed and sends them back to the respective students.
The use of quizzes and tests. The third strategy in eliciting evidence of student learning is the use of quizzes and tests. Teachers described providing tests and quizzes either in the middle of instruction or at the end. Teacher Hwang provides two problems that could be solved fairly easily within 5-10 minutes at the end of the class. He allows students to work individually or as a small group. Teacher Yoon provides several problem sets from the textbook at medium level. If students show achievement beyond 80%, he thinks that students have solid understanding. If students score less than 80%, he thinks students need supplemental instructions. Both teachers pointed out that these activities do not count towards student grades and serve a formative purpose.

Other teachers prepared formative-assessment worksheets, and/or a set of long-descriptive-answer problems. Teacher Kang provides a formative-assessment worksheet that consists of three problems at the end of instruction. Two are at medium- to low- level, similar to problems presented in the textbook, and one is at high-level requiring additional time and effort from students to solve. She allows more time for students to ponder the high-level problem and bring it home. The next day, she explains the problem, or has someone in the class present the solution.

Teacher Choi provides five to six problems at the end of the lesson to check students’ understanding of important math concepts. The problems involve higher-order thinking yet can be solved by applying core concepts taught during the lesson. After confirming in the beginning of the next lesson that everyone has had a chance to think about the problems, he has several students make oral presentations about their own solutions to share their strategies with the whole class. Other students can learn from this if they have not thought of the problem in the way a particular student describes. If he
thinks students’ solutions are incomplete or unsatisfactory, he intervenes to clarify, correct, or add onto them. He checks students’ various problem-solving strategies, and points out some parts that students are struggling with.

**Small group activities.** The fourth strategy in eliciting evidence of student learning is the introduction of small group activities, a bingo game about math terminology, and math journaling. Teacher Seo explained that the 2009 reform curriculum introduced good examples for small group activities and showed how to manage such activities. For example, she uses small group activities when teaching a unit on integral sums. The class has activities such as chopping donuts. The teacher focuses her attention on how students sum up the activity and make connections to mathematical concepts they are about to study.

When teaching a concept of numeric sequence or numeric progression, Teacher Seo introduces Hanoi Tower, an activity where students can have hands-on experience with numeric sequence. She allows students to spend some time working with Hanoi Tower. Through the activity, she discovers that students are engaged in collecting the data and noticing some patterns. She later has several students present the group’s findings. Making connections between working with concrete materials and finding abstract mathematical concepts during the concrete experiences are highly encouraged. Teacher Seo reported,

When teaching sequences, I apply Hanoi towers. Students become curious about the hands-on experience of Hanoi Towers. It is something that students can be engaged in doing as pre-schoolers or as middle school students. Initially, students just move the towers and later they become engaged in finding the patterns. I find
my students become active in those activities, and find them developing patterns or rules. Then, I have them summarize the data in a presentable format. … If there are students who can explain what they have been engaged to do by connecting it to mathematical concepts, I praise them.

Teacher Koh used bingo games to assess students with newly learned math terminology or to do problems that can be solved fairly easily. She explained,

When I was teaching at a middle school, I used to do terminology puzzles at the end of each chapter, or checking newly acquired math terminology with a bingo game. Five by five, twenty-five problems, is a bit much, so three by three, nine problems in a bingo game. Yes, problems that do not involve so complicated calculations, because students become exhausted if it takes too much time to figure out. So, I did bingo games or puzzles with problems that could be solved fairly quickly and easily.

Teacher Yang uses math journaling to encourage students to note the most difficult concept that was taught that day or things that students think are most important. Teacher Yang explained,

I used to do math journaling. I gave students five minutes at the end of instruction to note what was the most difficult to them or what was felt most important to them. Then, I had them write their overall impression of what was learned that day. – Ah, today was a little bit difficult. Something was understood, but other things were difficult to understand. I had them write these things at the end of each lesson.
Interpreting Elicited Evidence of Student Learning

Korean teachers acknowledged that information obtained through observation of students during instruction reveals more details about where students commit errors frequently and where they struggle the most. This acknowledgement is contrary to a long-held belief among U. S. teachers that student learning cannot be assessed validly through teachers’ firsthand observation, and that measuring by testing provides more valid and reliable results for gauging student learning (Erickson, 2007; Watt, 2005). In the interviews, Teacher Ahn said that information from formative assessment practices is usually more helpful for teachers to understand student thinking than information gained from summative assessments. Teacher Ahn believed this is the case because summative assessments, or schools’ regular exams, are mostly multiple-choice items that do not necessarily tell which part students get right and from which part on students get wrong. Korean teachers said that students’ verbal and written expressions help them understand student thinking. Verbal expressions include (a) student responses from teacher solicitation or elicitation, (b) discussion among students, and (c) student questions to their teacher. Written forms include solution strategies written on the board or in students’ individual notebooks.

Students’ verbal expressions. Teachers make use of students’ verbal and written expressions in three ways. First, having students express their thinking verbally helps teachers gauge the levels of student understanding. According to Teacher Choi, formative assessment is “checking to see if students are digesting the mathematical contents learned during the day and checking whether they are keeping up with acquiring content to make the knowledge their own.” Teacher Cho acknowledged,
Speaking out-loud helps to remember long-term what we are studying. To be able to express verbally, however, the student has to go through a deep thought process, review the content learned after class to acquire knowledge, and establish in their mind what has been learned.

Second, listening to the discussion among students helps teachers understand how much student thinking is progressing. For example, Teacher Yang pairs up students to work together to solve a problem. She overhears their discussion while they work in pairs. After some time has been spent on the problem, she has one student write down the pair’s solution strategy on the board and has the other student explain their strategy to the whole class. Teacher Kang has a student explain his or her strategy to the class. After the explanation is over, she asks if anyone in the class has any questions for the student presenter. Listening to a student raising questions and the student presenter answering the questions reveals a lot of information about the levels of student understanding and how far along the group’s thinking has been advancing.

**Students’ written expressions.** Third, teachers gain helpful information about student thinking by reviewing solution strategies written on the board by a student presenter, or by looking at individual students’ notebooks while the teacher is circulating around the class. For example, Teacher Koh checks whether there are mistakes in student solution strategies, whether students are taking appropriate steps, and whether there are students who are using methods different from what has been taught in class. These processes help teachers get a sense of the levels of student understanding, and to know on which parts students demonstrate mastery and on which areas students show a lack of
understanding. If there are conceptual items that students repeatedly get wrong, that
directs the teacher (Teacher Seo) to provide more instruction or extra exercise problems.

**Making Adjustments to Subsequent Instruction**

Assessment information can be interpreted in two ways: (a) information that is
derived from observations of students at work during instruction, such as while students
are answering teacher questions in whole-group instruction, when the students are
engaged in small group discussion, when they are presenting their solution strategies on
the board, or when they are working individually in their notebooks, and (b) information
that is derived from assessing students’ work in paper-based examinations.

**Assessment information from observation of students at work during daily
instruction.** I asked, “How do you use assessment information in designing/planning
your lessons?” The question was intended to ascertain how the teachers use assessment
information that is derived from observation of students at work during daily instruction
to inform their next lesson. The assessment information, derived by assessing students
on-the-spot during instruction, can be used in several ways. Teacher Koh explained it
very thoroughly:

First, it can shorten the gap between the level of student understanding and the
level of teacher’s instruction. To me, the instructional material becomes easier
because I teach the content to several different classes, yet there are areas where
students find it very difficult to understand. Second, teachers can adjust the
amount of instructional materials to be covered in a single class period. I stop and
think if I am covering too much content in a given time or too little. Third, it can
supplement the previous lesson. In the review of a previous lesson, I can explain
once again some topics that need further instructional intervention. Fourth, it
provides direction for the next instruction. It enables me to keep in mind that I
should emphasize certain points and provide detailed explanation of some areas
after finding that many students are struggling in those areas.

Many teachers provided details about how they use the assessment information to
supplement the previous lesson and guide their next lesson. When students are not able to
answer her questions on a concept, Teacher Cho recognizes that students lack
understanding in these areas, and that more explanation or further instruction is needed in
particular areas. She uses this information to supplement her next instruction. For
example, many teachers (Teacher Ryu, Teacher Hwang, Teacher Ahn, and Teacher Jeon)
remarked that they would re-teach or sometimes teach differently by adjusting (lowering)
the degree of difficulty. More specifically, Teacher Hwang and Teacher Jeon said that
they would provide many examples or make use of visual aids or multimedia to promote
understanding. Teacher Jeon acknowledged that observation of student work during
instruction had a direct influence of her next instruction. When she finds students having
difficulty on some parts, she emphasizes those parts when teaching other classes.

Teacher Kang tries to modify her instructional methods, or to reconstruct the
textbook material, to promote student understanding. Reconstructing the textbook
includes, according to Teacher Kang, “(a) reorganizing the sequence of lessons, (b)
adding some omitted contents, and (c) omitting parts that seem redundant or unnecessary.”
She made it clear that she is not trying to change the content of the textbook.

**Assessment information from paper-based assessments.** When I asked two
teachers (Teacher Yoon and Teacher Choi) how they use information derived from paper-
based assessments, it brought up different responses. Teacher Yoon reckoned that students who achieve more than 80% on long-descriptive-answer problems are doing well. Students who score less than 80% are given another opportunity to retake the test so that they can naturally review the content once again. Teacher Choi explained how the school uses the total sum of student scores on mid-term exams, performance assessments, and monthly mock-tests to change classes each semester. Students are assigned to classes with similar abilities. Teacher Yang has students keep notes of questions that they answered incorrectly on paper-based assessments. In the notebook, students are asked to write down the question, solution strategy, and the answer. Upon receiving submission, the teacher checks the notebook. If the solution strategy is inaccurate, the student is asked to revise and resubmit the notebook.

**Obstacles Implementing Formative Assessment**

As I interviewed Korean teachers, they reported a few obstacles hindering teachers from practicing sound formative assessment: (a) Time is too limited to cover all instructional materials within a set period; (b) there are too many students in each class for teachers to pay attention to all of the individual students’ performance; (c) some students show low participation in classroom activities, and; (d) some teachers, administrators, parents, and students think that formative assessment is subjective.

First, there are time constraints to cover all instructional materials within a set amount of period (Teacher Ryu, Teacher Kang, and Teacher Cho). Teachers are expected to deliver a set amount of content within a year. They wish to have all their students solve all the problem sets, but they confront time limits to cover all problems. They cannot always do formative assessment. Teachers said that they have little time to conduct
formative assessment. Teacher Kang said that the number of math classes per week will be reduced from four hours to three hours a week starting from year 2014. This means that teachers will be busy covering all the contents and less time will be devoted to other things such as formative assessments. In this situation, there will be a shortage of time for teachers to deliberate about formative assessment practices.

Second, there are too many students per each class for teachers to pay attention to individual students’ performance (Teacher Jeon). The first and second obstacles are well documented in the literature. There are pressures from outside the classroom, such as having to follow a strict schedule (Erickson, 2007). In addition, there are pressures from institutions (standards, curricular materials, and district testing), key stakeholders (students, parents, and administrators), and teachers’ own personal pressures (Saxe, Gearhart, Franke, Howard, & Crockett, 1999).

Third, some students stay inactive in classroom participation (Teacher Choi, Teacher Yang, Teacher Koh, Teacher Ahn, and Teacher Hwang). Teacher Yang said that when she gives time for students to discuss a problem in small groups to get ready for their presentations, some students use the time unwisely by trying to re-acquaint with friends chatting about things unrelated to the class work. Likewise, Teacher Koh said that when she wishes to spend time with students sharing different ideas and strategies they might have, some students show bystander attitude, not wanting to participate in the whole group discussion.

Teacher Ahn pointed out an important thing. She observes that most of the time, students do not opt to come to the board and share their solution strategies because they are afraid of revealing mistakes in their solution methods in public.
However, when a student presents his or her work and shows some mistakes, it is often the case that a handful of other students might be experiencing the same problem. By going through the process, I can understand which parts students are having the most difficulties with, and that enables me to provide help by offering explanations. But students tend to want to show only their strengths. I tell students it is good to commit mistakes, but from students’ viewpoint it is not, and it makes it difficult for them to come to the front and show their work.

Finally, formative assessment can be perceived as being subjective, an important point that the literature also documents (Erickson, 2007). Teacher Seo said that there needs to be some faith established between teachers and students. In some instances, students might raise complaints about why they received lower points when their peers got a higher grade whose method seem to them similar to their own. It is critical that teachers practice “clinical judgment” (Erickson, 2007) in their lessons, have clear communication about their expectations of their students, and build faithful relationships with their students.

**Discussion**

I have to make it clear in the first place that math teachers in Korea are highly qualified. They receive appropriate pre-service teacher education through undergraduate studies, and take national teacher employment test to become teachers. The teachers continue to be educated through professional development programs and by pursuing higher degrees. The teacher participants involved in this study all have educational background in math education for undergraduate studies, and they all have pursued and received master’s degrees in math or math education.
In addition, it has to be noted that there is little difference between public and private schools in terms of resource and curriculum, because both sectors are controlled by the government. However, since mid-1990s, there has been a shift from the above egalitarian approach to the marketized and privatized approach in the upper secondary schools. Thus, high-performing middle school students tend to apply for the special-purpose high schools (that came from school specialization) and independent private high schools (that came from school privatization).

Despite the distribution of high-qualified teachers across the country and little difference between private and public sectors, many Korean scholars (Oh, 2011; Park, 2007) increasingly report that there is a wide gap between students from families of different socio-economic status (SES) in South Korea. The achievement differences and its relationship to SES is a concern with the Korean Ministry of Education. Byun and Kim (2010) examined the relationship between SES and student achievement using three most recent TIMSS data (1999, 2003, and 2007) by comparing the results of South Korea and those of the U.S.:

First, although the relationship between SES and student achievement tended to be stronger among the recent cohorts (2007) than among the earlier cohorts (1999) in both South Korea and the U.S., it tended to be stronger among the students in South Korea than among those in the U.S. For example, the influence of SES explained 13% variance in math performance in 1999, and 17% in both 2003 and 2007 in South Korea. In the U.S., the proportions were 10%, 14%, and 13% in 1999, 2003, and 2007 respectively. Second, the influence of SES on student achievement has increased over time in South Korea. SES was associated with an
average performance difference of 25 score points in 1999, 29 score points in 2003, and 32 score points in 2007 in South Korea. This tendency was less evident for the U.S. The corresponding average score differences remained in the range of 17-18 score points. (pp. 173-174)

Three reasons could be speculated about the widening gap between advantaged and disadvantaged groups in Korea. First, the growing gap in shadow education opportunity between high-income and low-income children may lead to a gap in student achievement between the two groups (Byun & Kim, 2010, p. 165). Second, educational transformation from the egalitarian to the market-based approach could contribute to the widening SES gap in student achievement by limiting educational opportunity for low-income students (p. 166). Third, it has been reported that U.S. teachers tend to use conceptual instruction more with high-performing students than with low-performing counterparts (Akibe, LeTendre, & Scribner, 2007, p. 369). For example, Teacher Jeon expressed in the fifth interview that student achievement levels would matter when she teaches. She explained that there is a tendency among low-performing students not to express their mathematical thinking when they are asked to answer a teacher question. She further said that she would conduct divergent formative assessment (in other words, teach conceptually) with high-performing students and take convergent approach (in other words, teach directly) with low-performing students.

**Teachers’ Use of Formative Assessment and the Socio-Economic Status (SES) of their Students**

It has to be noted that there is little difference between public and private schools in Korea because both sectors are controlled by the government. The socio-economic
status (SES) of students can be inferred by examining where the schools are located, in the large city or in the smaller city. Usually schools that are located in the large city tend to have high-SES students and schools located in smaller city tend to have low-SES students. However, there are exceptions. There are schools located in smaller cities that have a high reputation and attract high-performing students from across the province or from across the entire country. For example, some special-purpose high schools and independent private high schools are located in the smaller cities. Table 8 summarizes teachers’ use of formative assessment practices, and I have included the locations of the schools to infer the SES of their students.

Table 8

*Teachers’ Use of Formative Assessment and the SES of their Students*

<table>
<thead>
<tr>
<th>Type of School (Public/Private)</th>
<th>Formative Assessment Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Middle School</strong></td>
<td></td>
</tr>
<tr>
<td>Teacher Ahn (F)</td>
<td>Public middle school (Small city)</td>
</tr>
<tr>
<td>Teacher Yang (F)</td>
<td>Public middle school (Small city)</td>
</tr>
<tr>
<td>Teacher Kang (F)</td>
<td>Public middle school (Largest city in the Province)</td>
</tr>
<tr>
<td>Teacher</td>
<td>Type of School (Public/Private)</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Teacher Shim (F)</td>
<td>Public middle school (Small city)</td>
</tr>
<tr>
<td>Teacher Jeon (F)</td>
<td>Public middle school (Largest city in the Province)</td>
</tr>
<tr>
<td>Teacher Ryu (F)</td>
<td>Private middle school (Small city, but the school has a good reputation)</td>
</tr>
<tr>
<td>Teacher Cho (F)</td>
<td>Private middle school (Largest city in the Province)</td>
</tr>
</tbody>
</table>

**High School**

<table>
<thead>
<tr>
<th>Teacher Seo (F)</th>
<th>Public high school (Small city)</th>
<th>Homework assignments; Use of quizzes and tests; Examining student solution strategies on their notebook; Student written and oral presentations; Small group activity with hands-on experiences (e.g., Hanoi tower) – have students summarize their activity making connection to mathematical ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Koh (F)</td>
<td>Public high school (Largest city in the Province)</td>
<td>Questioning and solicitation of student answers; Quizzes without scores; Practice solving example problems, similar problems, and exercises; Student oral presentations; A bingo game about terminology; Examining solution strategies on long-descriptive-written assessment</td>
</tr>
</tbody>
</table>
While the focus of this study was not about the relationship between teachers’ views of formative assessment and the socio-economic status (SES) of their students, nonetheless, the following patterns were detected. The discussion focuses on the patterns represented in Table 8.

First, among high-SES middle schools there was a tendency for the teachers to conduct discourse-based formative assessment practice (DAP). For example, Teacher Jeon, Teacher Ryu, and Teacher Cho used student written and oral presentations to have students share their solution strategy with the class, provide further teacher explanation, have student re-explain, and encourage discussion among students. There was an exception. Teacher Ahn, although her school was located in a small city, also conducted high-quality DAP. She used teacher questioning and solicitation of student answers to gauge the levels of student understanding as an individual and as a whole group.

Second, among high-SES high schools there was a tendency for the teachers to adopt the new assessment policy put forth by the government. For example, Teacher Koh,
Teacher Yoon, and Teacher Choi all worked hard to prepare their students for the long-descriptive-written assessment through classroom instruction and through teacher-prepared paper-based assessments. Teacher Yoon and Teacher Choi explained thoroughly that they grade students’ work, make the score public, and go through appeal process during class periods.

Third, I found that teachers with relatively smaller number of teaching experiences tended to incorporate more reformed formative assessment practices. For example, Teacher Yang (4 years), Teacher Kang (8 years), and Teacher Seo (5 years) incorporate math journaling, mentor-mentee activity, portfolio assessment, and small group activities with hands-on experiences.
Chapter 5

Teachers’ Formative Assessment Knowledge through Examining Student Work

According to Black and Wiliam (1998, 2009) and Stiggins (2010), formative assessment involves: (a) creating high-quality assessment tasks before instruction, (b) eliciting student learning, (c) interpreting the evidence gathered of student learning, (d) communicating assessment results to students during instruction, and (e) making adjustments to subsequent instruction after instruction. I found that Korean teachers’ formative assessment practices and strategies fall into three broad categories: (a) eliciting student learning, (b) interpreting evidence gathered of student learning, and (c) making adjustments to subsequent instruction.

Bennett (2011) points out that among assessment activities, literature pays little attention to the latter two significant processes: interpretation teachers make of evidence gathered and the instructional actions teachers take. Heritage, Kim, Vendlinski, and Herman (2009) point out that while teachers do better at drawing inferences about or evaluating students’ levels of understanding, they have difficulty in planning further instructional steps based on the evaluation of students’ understanding. To overcome this, teachers need to use their “professional clinical judgments” (Erickson, 2007, p. 190) or their “pedagogical content knowledge” (Shulman, 1986, p. 9). According to Shulman (1986), pedagogical content knowledge is a particular form of content knowledge, and it represents and formulates the subject to make it comprehensible for students. Teachers can use “analogies, illustrations, examples, explanations, and demonstrations” (p. 9).

In this chapter, I examine teachers’ formative assessment knowledge through three different tasks: (a) examining a student’s work on a two-digit multiplication
problem, (b) examining students’ work on part-and-whole relationships of fractions, and (c) examining scenarios of a lesson on the laws of exponents. Through these activities, I tried to capture what interpretations teachers make of the students’ work, and how they would teach differently moving forward.

The first task is modified from Crockett (2012, April). In the task, a student’s solution to a two-digit multiplication problem was presented to teachers. Teachers were then asked several questions regarding (a) examining and interpreting student misconception, and (b) using evidence of student learning to inform subsequent instruction. While teachers may find it easy to evaluate students’ understandings or the lack of understanding, they may have difficulty using the evidence of student learning to plan the next instructional step (Heritage, Kim, Vendlinski, & Herman, 2009). Through this activity, I planned to explore teachers’ “pedagogical content knowledge (PCK)” (Shulman, 1986, p. 9), and how they would use their “professional clinical judgments” (Erickson, 2007, p. 190) to represent/formulate the content to make it comprehensible to students.

The second task is taken from Lamon (1999). Three students’ written explanations to part-whole comparisons of fractions were presented to the teachers (p. 59). Teachers were then asked to “analyze student responses, rank strategies according to their sophistication, and give reasons to support the ranking” (p. 75). The goal is to provide experiences in six areas (i.e., relative thinking, unitizing, partitioning, rational numbers, ratio sense, and quantities and change) to contribute to an understanding of proportional reasoning (p. 3). According to Lamon, a part-whole comparison is “used to compare one or more equal portions of a unit to the total number of equal portions into
which the unit is divided” (p. 60). The part-whole comparison task is important because it is based on students’ prior understandings of relative and absolute thinking, fractions, and units and unitizing, which would lead to an understanding of more advanced concepts such as rational numbers, ratios, and rates.

In the third task, classroom scenarios are adapted from Lampert (1990) to fit the purposes of the interview. The two classroom scenarios, in which a teacher and students are working on exponents, were shown to the teachers. In both scenarios, the objectives of the lesson is to teach a law of exponents: that when two numbers with exponents that have the same base are multiplied, the base remains the same and the exponents can be added (i.e., \( n^a n^b = n^{a+b} \)). The first scenario is an illustration of “convergent assessment” exchange, while the second is representative of “divergent assessment” exchange (Pryor & Crossouard, 2008). Teachers were then asked several questions about the scenarios: overall impressions of the scenarios, opinions about two approaches to teaching and learning, and what they would do differently. Teachers’ understanding about discourse-based formative assessment practices (DAP) can be explored through this activity.

**Two-Digit Multiplication Problem: Exploring Teachers’ Pedagogical Content Knowledge (PCK)**

Below, I include the actual task teachers were asked to view. The exhibit questions below are derived and modified from Crockett (2012, April). These can be found in Appendix B.

*Eliciting and collecting evidence of student learning:*

Sixth grade teachers have noticed that several of their students solved the following two-digit multiplication problem in this way:
Examining and interpreting student misconceptions:

a) What is the correct answer?
b) What type of problem is this?
c) What are the strengths and weaknesses of the student’s work?
d) What are the mathematical concepts and ideas at play in this problem?

Using evidence of student learning to inform instruction:

a) What instructional strategies would you employ so that the student can solve the problem with understanding?
b) If you were to use manipulatives, which would you use, how would you use them and why?
c) What questions would you ask to ensure mathematical understanding prior to, during, and after teaching?
d) What feedback would you provide to this student and why?

A student’s solution to a two-digit multiplication problem (12x34) was presented to the teachers (12x34; 48+36; 84). To examine how teachers interpret student misconception, the following four questions were asked: (a) What is the correct answer? (b) What type of problem is this? (c) What are the strengths and weaknesses of the student’s work? And (d) What are the mathematical concepts and ideas at play in this problem?
To examine how teachers would use the evidence elicited of student learning to inform subsequent instruction, the following four questions were asked: (a) What instructional strategies would you employ so that the students can solve the problem with understanding; (b) if you were to use manipulatives, which would you use, how would you use them and why; (c) what questions would you ask to ensure mathematical understanding prior to, during, and after teaching; and (d) what feedback would you provide to this student and why?

Ma (1999) provides a knowledge package for multiplication by multi-digit numbers. The following components inform multiplication by two-digit numbers 12 x 34: “(a) multiplication by one-digit numbers, (b) the concept of place value system, (c) how a number is composed, (d) meaning of multiplication, (e) multiplication by 10 and powers of 10, and (f) the distributive law” (p. 47).

First, teachers all agreed that the student is good at multiplication by one-digit and two-digit numbers, because the student correctly solved both 12 x 4 and 12 x 3. Second, all teachers agreed that the student lacks place-value understanding that the three in thirty-four actually means thirty, because it is in the tens place. Third, Teacher Shim pointed out that a two-digit number is composed of ones and tens place, so thirty-four is composed of thirty and four. Fourth, Teacher Jeon pointed out that the student is lacking understanding of the meaning of multiplication, in that 12 x 34 means that one has to add twelve, thirty-four times. Furthermore, it can be decomposed to mean adding twelve thirty times and adding twelve four times, and combining the results. Fifth, Teacher Jeon acknowledged that the problem entails multiplication by tens and powers of tens. Finally,
Teacher Jeon and Teacher Koh explained how the distributive law is applied in this problem in detail. Teacher Jeon explained,

The distributive law is applied. Thirty-four can be decomposed into thirty and four. Thus, you can calculate 12 x 30 and 12 x 4 and add them. Originally, you have to add twelve thirty-four times, but instead you can add twelve four times and add twelve thirty times.

Teacher Koh explained, “When you multiply 12 by 34, you multiply 12 by (30 plus 4). So, you multiply 12 by 30 and multiply 12 by 4, and add them.”

**Instructional Strategy**

When I asked, “What instructional strategies would you employ so that the student can solve the problem with understanding,” four teachers (Teacher Ryu, Teacher Choi, Teacher Shim, and Teacher Kang) elaborated the concept of place value system; one teacher (Teacher Ahn) elaborated how a number is composed; two teachers (Teacher Cho and Teacher Jeon) elaborated the meaning of multiplication; three teachers (Teacher Koh, Teacher Yang, and Teacher Seo) elaborated multiplication by 10 and powers of ten, and; three teachers (Teacher Cho, Teacher Seo, and Teacher Hwang) elaborated the distributive law.

First, Teacher Ryu, Teacher Choi, Teacher Shim, and Teacher Kang emphasized the concept of a place value system, that 3 in 34 means 30 as in tens place, not 3 as in ones place.

Second, Teacher Ahn’s explanation about how a number is composed is representative of other teachers’ responses. For example, Teacher Ahn indicated that she would teach decimal expansion (34 = 3x10 + 4x1) to elaborate what a number (34) means.
3 in 34 means 30 because it is in tens place, and 4 in 34 means 4 because it is in ones place. She explained how she would teach toward a symbolic representation,

I would ask students, if a number in tens place is called $a$, and a number in ones place is called $b$, then how can it be expressed? And the answer is $10a + b$, not $ab$, like what most students would say.

Third, Teacher Cho and Teacher Jeon elaborated the meaning of multiplication. Teacher Jeon gave a basic example that 2 times 3 means adding 2 three times ($2 \times 3 = 2+2+2$). So, 12 times 34 means adding 12 thirty-four times. She went on, saying, “I would tell students that they can add 12 thirty times ($12 \times 30$), add 12 four times ($12 \times 4$), and combine the results.” In addition, Teacher Cho said that since $12 \times 30$ is addition of 12 thirty times, the result is 360, not 36. She explained, “I would make students realize where to put 360 in the long multiplication.”

Fourth, Teacher Koh, Teacher Yang, and Teacher Seo elaborated multiplication by 10 and powers of ten. Teacher Seo said, “I would let my students realize the difference between $12 \times 3$ and $12 \times 30$. If they compute, they would know right away that $12 \times 30$ is much larger number.” What Teacher Seo emphasized here is to teach the number sense. Teacher Yang said that she would teach multiplication of a two-digit number and powers of ten, such as $12 \times 10$, $12 \times 20$, $12 \times 30$, while Teacher Koh indicated that she would make students understand that they are multiplying 12 by 30, not by 3.

Finally, Teacher Cho, Teacher Seo, and Teacher Hwang elaborated the distributive law. Teacher Hwang said, “I would teach students that 12 is composed of 10 and 2, that 34 is composed of 30 and 4, and that $12 \times 34$ is a multiplication of $(10+2)$ and
(30+4).” Similarly, Teacher Seo and Teacher Cho each indicate that they would teach students 12x34 is a multiplication of 12 and (30+4).

**The Use of Instructional Manipulatives**

When I asked, “If you were to use manipulatives, which would you use, how would you use them and why,” many teachers answered they would use a ones cube, tens block, and hundreds flat. However, their strategies differed significantly. Two teachers (Teacher Hwang and Teacher Cho) used the ones cube, tens block, and hundreds flat to represent an area model. Three teachers (Teacher Koh, Teacher Shim, and Teacher Ahn) incorporated bundles concept with the same manipulatives. Teacher Koh made use of a stones-in-boxes model, a similar approach to the bundles concept. One teacher (Teacher Jeon) used the ones cube, tens block, and hundreds flat to teach the place value concept.

First, Teacher Jeon used the ones cube, tens block, and hundreds flat to teach the concept of place value. She explained that 3 in 34 is composed of three tens-blocks, and that 4 in 34 is composed of four ones-blocks:

I would make it clear that the place in a number is different. I would emphasize that 3 in 34 is three tens not three ones, and it can be effectively demonstrated by the ones cube and tens block, because their size makes the difference evident.

Second, Teacher Hwang and Teacher Cho used the ones cube, tens block, and hundreds flat to represent an area model. They would put 12 on the bottom and 34 on the side. On the bottom, they put one tens-block and two ones-cubes. On the side, they put three tens-blocks and four ones-cubes. They explained that the area inside the rectangle is the answer looked for. Teacher Cho added that this model is also frequently used when teaching factors.
Third, both Teacher Ahn and Teacher Shim used the ones cubes, tens blocks, and hundreds flats, but they used them to represent a bundles concept, not an area model. Teacher Ahn and Teacher Shim explained that there are thirty bundles of 12 (12x30) and four bundles of 12 (12x4), and they can be combined together, 12x30 + 12x4 = 12x(30+4) by the distributive property. Teacher Ahn anticipated that four hundreds-flats will be used because the answer is 408.

Fourth, Teacher Koh came up with a different instructional tool, stones-in-boxes, using a similar approach as in the bundles concept. For example, she introduced a box that contains twelve stones. If there are four boxes of this kind, then the stones inside are (12x4) forty-eight. If there are thirty boxes of this kind, then the stones inside are (12x30) 360. The stones in the four boxes (12x4) and those in the thirty boxes (12x30) can be combined together (12x4 + 12x30) to get the result.

**Questioning and Feedback**

When I asked, “What questions and feedback would you provide to ensure mathematical understanding prior to, during, and after teaching,” teachers provided various answers. Before instruction, teachers answered that they would ensure (a) students’ understanding of the meaning of multiplication, that repetitive addition can be simplified with multiplication; (b) understanding of the decimal system, that what we use in real life is expressed in decimal numbers, and; (c) understanding of the concept of place value, that the place of each digit is important. To promote number sense, Teacher Seo would ask a set of questions about students’ understanding of currency, such as, “Would you prefer to have 10 times as much as 10 won, 5 times as much as 10 won, 5 times as much as 100 won, 5 times as much as 1000 won?” She anticipated that because
students are acute about currency, they would realize quickly that it would make a big
difference where a number is placed. Additionally, teachers (Teacher Ryu, Teacher
Hwang, and Teacher Shim) would make sure that students are good at one-digit
multiplication and multiplication by two-digit and one-digit numbers, such as 12x3 and
12x4. Other teachers (Teacher Yang and Teacher Cho) would ensure that students know
how to perform multiplication by tens or powers of ten, such as 12x10, 12x20, and 12x30.

During instruction, teachers introduced various strategies to teach two-digit
multiplication. To ensure understanding of the place value concept, Teacher Jeon would
ask, “If I ask you to perform 12 times 56, what does 5 mean? It means 50 composed of
five tens, not 5 composed of five ones. The position in which a number is placed makes a
difference.” Teacher Shim would ask a series of questions, “What is 12x3? 12x4? And
12x30?” in order to convey the difference between 12x3 and 12x30. Then, she would
teach the distributive property – that 12x34 is an addition of 12x30 and 12x4. Teacher
Ahn introduced how to teach the distributive property in long multiplication format so
that students can visualize it (12x34; 4x2=8; 4x10=40; 30x2=60; 30x10=300;
8+40+60+300=408). Other teachers would provide additional two-digit multiplication
problems (e.g., 12x41, 12x45, and so on) that are similar to the original problem 12x34.

After instruction, teachers indicated that they would make it clear to students that
12x34 is the addition of 12x4 (12 times 4, as in ones place) and 12x30 (12 times 30, as in
tens place). They would make sure students do not confuse 12x30 with 12x3, and make
them realize what they wrote as 36 is in fact 360. In particular, Teacher Hwang would ask
students to compute 34x12 and check the result with 12x34 to see if they get the same
result by the associative property. Teacher Koh, who used the stones-in-boxes approach,
said, “I would have students realize that the number of the stones and the result they have do not match, and provide instruction on the place value concept so they can revise work and perform appropriately.”

**Part-and-Whole Comparisons: Exploring Teachers’ Pedagogical Content Knowledge (PCK)**

Below, I include the actual task teachers were asked to review. The task is taken from Lamon (1999). Children’s strategies to solve a problem investigating part-whole comparisons were presented to teachers. These can be found in Appendix B. The problem posed to students is as follows: “Name the part that is shaded in each picture. (See Figure 1.) Do these fractions name the same amount? How do you know?” (Lamon, 1999, p. 59)

1Figure 1. Shaded Part in Each Picture

(Republished with permission.)

Three students, Mike, Adam, and Derek, answered as follows:

Mike: In the circle 2/2 is shaded. In the box 4/4 is shaded. They can’t be the same amount because one is a box and one is a circle.

Adam: ½ is shaded in both pictures. It is the same fraction but not the same amount. You can tell like this. (See Figure 2.)

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I posed the following question to the teachers during the fifth interview: “Analyze the children’s responses. Are they correct? Rank the strategies according to their sophistication, giving reasons to support your ranking” (Lamon, 1999, p. 75).

I chose this problem with three students’ written responses and posed this particular question to the teachers for a couple of reasons. The students’ responses (Mike, Adam, and Derek’s) brought up images I developed about the long-descriptive-written assessment that is increasingly emphasized in Korean public education. I thought that if Korean students were asked to write their solution process as well as their solution, Mike, Adam, and Derek’s written responses would be similar to what Korean students are asked to do in filling out their answer sheet.

Moreover, I anticipated that the question posed to the teachers would prompt processes similar to what Korean teachers would do for grading the long-descriptive-written assessment. Teachers related that they hold multiple departmental meetings to revise the scoring guide and to share opinions with other teachers about how to grade. I think that the question, asking teachers to analyze students’ responses, rank strategies, and give reasons to support the ranking, constituted a starting point for discussion similar
to what Korean teachers are engaged in doing when grading long-descriptive-written assessments, which is an iterative process.

Lamon (1999) discusses students’ difficulties (p. 66). Mike interpreted the pictures with ratio rather than part-whole comparisons. However, he may have understood that they are not equivalent because different units were used. Adam understood that the same fraction is derived from both pictures. However, he used visual reasoning to determine the equivalence of the area shaded in each picture, rather than addressing that the fraction ½ referred to a different unit in each picture. Derek identified the correct fraction in each picture, but failed to recognize that they refer to different areas.

Korean teachers had differing opinions about students’ strategies. Seven teachers (Teacher Ryu, Teacher Jeon, Teacher Kang, Teacher Koh, Teacher Cho, Teacher Ahn, and Teacher Hwang) supported Adam’s strategy, that “the shaded area can be expressed as one-half in both pictures” and that “it is the same fraction but not the same amount.” Four teachers (Teacher Seo, Teacher Shim, Teacher Yang, and Teacher Yoon) supported Derek’s strategy, that “the shaded area can be expressed as one-half in both pictures” and that “they are the same amount because half the picture is shade.” One teacher (Teacher Choi) indicated that his response would be different according to how the question could be interpreted. In this section, I documented teachers’ difficulties or differing opinions about interpreting students’ strategies. The difficulties have implications for how teachers “interpret” students’ work, which is important in formative assessment.
Seven Teachers Supported Adam’s Strategy

It matters which object we begin with. Among the seven teachers who favored Adam’s strategy, three teachers (Teacher Ahn, Teacher Jeon, and Teacher Koh) supported his strategy on the grounds that when we measure “one-half of something” we initially begin with an object. Teacher Ahn claimed that it makes a difference “which object we begin with” when measuring its half.

Teacher Ahn: (for Adam) If we want to see if the amount is same, we need to decide what is the given unit at the beginning. If the given amount is the same at the beginning for each object, then one-half of them would be the same. However, when we begin with different objects such as a rectangle and a circle, then a half of a rectangle and a half of a circle can be different. Adam also has good understanding of fractions.

Derek understands well that 2 out of 4, and 4 out of 8 is shaded. He understands the concept of fractions, but lacks understanding in the part-whole relationships. He does not recognize that we did not start with the same object at the beginning.

Teacher Jeon used a term, “standard or benchmark” (기준), similar to a concept brought up by Teacher Ahn, to mean the starting object.

Teacher Jeon: (for Adam) Fraction is the ratio, the ratio of some part out of a whole. 1 out of 2. Then, is it the same amount? Similar to the concept that a half of an apple and a half of a pear are different, I think I can say that the amount would be different. We can clearly see that the amount of two quarter-circles and four right triangles are different.
Derek approached getting the one-half the same as Adam. But one thing we have to consider is that when we say an amount is one-half or one-third of something, we are referring to a benchmark/standard (기준). The standard for one is a circle and another is a rectangle. Because we have different standards, the amount of the shaded areas of the two pictures cannot be the same, I think. Derek got it right on the one-half, but the latter part on comparing the amount is different than what I think.

(for Mike) I think Mike does not have a good understanding of the meaning of fractions, so he could not express the shaded part of the figures in fractions. And then, he says, “They can’t be the same amount because one is a box and one is a circle,” which I think is less sophisticated.

Teacher Koh also emphasized that “the whole” that we began with when we measure its half is important.

Teacher Koh: Mike does not have a firm understanding about getting the ratio between a part and the whole. But, when he derives the fact that they can’t be the same amount, he grounds his reason that it is because the two figures as a whole are different, which is correct. He got the result right, but there is visible lack of understanding in the process getting to the result.

Adam derived \( \frac{1}{2} \) from the shaded part of the whole in the figures, and says that they are the same fraction but not the same amount, because it is a ratio of a part from the whole. He recognizes that a fraction is a relative proportion of a part compared to the whole.
(for Derek) The concept of a half is the same. Derek does not understand the concept of a ratio, a half out of a whole, or a half out of an object. He got right that it is half of a whole in the process, but went in the wrong direction because of the lack of understanding of the concept of relative proportion. On the other hand, when we consider just the value of it, 2 out of 4 and 4 out of 8 could be understood as having the same value. So if Derek was thinking about the value of the fractions, not the amount of the shaded area in the figure, then there is some possibility that Derek’s answer has some feasibility. But, I think the question asks the ratio of a part from the whole object, so Derek got the wrong result.

When I asked her to explain on what she meant by “it is a half out of an object,” Teacher Koh elaborated:

Teacher Koh: When we try to measure a half of something, we bring a half of a given value or a half of a given shape. When measuring the amount, the circle itself, or the rectangle itself, or the object itself as a whole, was different originally, so the amount of the half of them would be different. In case of Derek, he perceived the whole as 1, then interpreted the shaded area as a half of that 1, and drew the result that they are the same. He should have focused on what was the whole object, but instead based his reasoning on the fact that it is a half, and got the wrong result.

The “area” of the shaded part is different. Among the seven teachers who favored Adam’s strategy, four teachers (Teacher Cho, Teacher Kang, Teacher Hwang, and Teacher Ryu) supported his strategy on the grounds that the “area” of the shaded part
is different. Teacher Kang interpreted the amount as “an area of the shaded parts” of the figures.

Teacher Kang: Mike should have expressed the shaded parts compared to the whole in a ratio form, and translated the ratio into a fraction, but he lacks understanding of the relationship between the shaded part and the whole. Derek expressed the ratio of shaded part to the object in fraction well. *The amount refers to the area of the figure. Although the ratio is the same, the area generally is not the same.* But, Derek reasoned that because the ratio is the same the amount would also be the same, and that’s where he missed the point.

Adam expressed the ratio of shaded part to the whole object in fraction well. Additionally, he overlapped the two figures to compare the amount of the shaded areas, and confirmed through the pictorial representation that the amount is not the same, that even though the ratio could be the same, the amount is not, because the whole object is different.

Teacher Hwang’s opinion resonated with Teacher Kang that the amount is different because the area of the shaded part is different.

Teacher Hwang: Adam says, “a half of a circle is ½, and a half of a rectangle is ½. They are the same fractions but not the same amount.” There is no unit of length provided in the problem. *Since the area is different, I can say that the amount is different.*

Derek reasoned that since the fraction is the same the amount is the same. But, the actual amount would be different. *In Derek’s case, he thinks the amount is same because a half of the whole object is shaded. Not taking into account the concept*
of area, Derek thinks that since the value of the fractions is same, they are the same.

Teacher Cho used a term, “absolute amount,” to explain her reason to support the ranking.

Teacher Cho: (for Mike) the part of a whole amount, a fraction, refers to the ratio of the part to the whole amount. Mike doesn’t seem to have the understanding of the concept of a ratio, the shaded parts to the whole amount.

Adam does know that the ratio is ½, if it is 2 out of 4 or if it is 4 out of 8. He says, “It is the same fraction, but not the same amount.” This means that the absolute amounts are clearly different, but the ratio itself is the same. So he means that the fraction is the same. In other words, it has the same ratio, but the absolute amount is different. They can’t be the same amount – it means that the value itself is different. I doubt that the pictorial representation Adam provided is an appropriate one, because we don’t know what value they have, whether the circle is inside the rectangle or outside the rectangle, we don’t know. Anyway, Adam has a good basic understanding of the ratios, fractions, and the rational number system.

Derek says, “2/4 is colored, and 4/8 is colored, and they are the same.” When he says “they are the same,” I think he is referring to the ratio itself. He only considered the ratio, but didn’t take into account the absolute amount – in other words, the absolute amount of the specific area. Derek does not take into account the area or absolute amount. Because when he says, “they are the same,” it means the ratio itself, the ratio of 2 to 4 and the ratio of 4 to 8. If he were to be
precise, he should have written or mentioned, “the ratio is the same” or “they have the same value as a fraction.”

When I asked Teacher Cho to elaborate what she meant by the “absolute amount,” she explained:

Teacher Cho: I mean the actual area as in “what is the area of a circle when the radius is something.” They are different. The person who tells this point is Adam. “They can’t be the same amount, although they are the same fractions” – this means that the ratio is the same but their actual area is different. They both name a half of an area, the ratio is the same but the unique amount of the area is different.

After looking at the problem I posed to her, Teacher Ryu shared with me her feelings toward the problem: “I think it is a problem trying to measure students’ creativity. When the problem asks if it is the same amount, they don’t provide the size of the shapes. We don’t know whether they have the same width or things like that. Instead of requiring a specific answer from students, I think the problem asks what students think of a concept of a ratio or fractions.” Teacher Ryu, then, gave reasons to support her ranking. She also made direct reference to the “area” of a shape when supporting her reasons:

Teacher Ryu: Mike did not express the ratio itself in an appropriate manner. But when he answers about the amount, the amount can’t be the same when they have different shapes – I think he got this part right.

Derek does know the meaning of fractions. When he says they are the same it refers to the ratio, not what the teacher is intending to ask about the amount. He knows the meaning of fractions, but missed one point.
When he expressed that it is 1/2, he knows about the ratio. He also expressed that the amount can’t be the same, meaning that he went deeper to see the shapes. According to how the shape is given, it can be the same amount or different. But, actually, it is difficult to have the same area of a circle and a rectangle. A circle has a pi, an irrational number, in itself, so it is difficult to create a rectangle with the same area as a circle. *Adam thinks that the circle is placed inside the rectangle, but actually the size is not provided. Here in the problem, whether the teacher intended the expression of fractions or the area of the shaded part, is not clear. So these different responses came up. Yet, Adam catches two things: that the value of the fraction is the same but that the actual amount is different.*

**Four Teachers Supported Derek’s Strategy**

Four teachers (Teacher Seo, Teacher Shim, Teacher Yang, and Teacher Yoon) favored Derek’s strategy, that “the shaded area can be expressed as one-half in both pictures” and that “they are the same amount because half the picture is shade.” Teacher Seo, Teacher Shim, Teacher Yang, and Teacher Yoon interpreted the problem and saw that the whole circle can be abstracted into a numeric number 1, and that the whole rectangle can also be abstracted into a numeric number 1. Since they abstracted a numeric value, 1, out of the two different shapes, the halves of each of them are the same.

Teacher Seo: Derek can express in fractions the parts from a whole unit. Adam does not see that 1, a numeric value representing a whole circle, and 1, a numeric value representing a whole rectangle are the same 1. He is not able to generalize it into symbols out of pictorial representation. But, the fact that he
expressed each into $\frac{1}{2}$ tells that he has good understanding of the concept of fractions.

Mike does not know the numerator and the denominator, and made an error in checking the parts from the whole.

Teacher Shim’s response resonated with Teacher Seo’s:

Teacher Shim: Derek knows the concept of a whole, regardless of whether it is a circle or a rectangle. The concept of a whole. Since he knows that the whole represents a numeric value 1, its half is $\frac{1}{2}$.

Adam understands the fraction, the half of a whole. But, the concept in focus is not whether it is a big circle or small circle, it is not a concept of an area. Its focus is the fraction itself, the number itself – we should consider whether the number is bigger or smaller. I think we should look at the concept of a number, not the concept of an area or an amount.

Mike does not know how to express a half in fractions. Also, because he compared the amount of a circle and rectangle, it creates a problem.

Teacher Yang made it clear that she is also considering the problems as a symbolic representation that is derived from a pictorial representation.

Teacher Yang: (for Mike) When he says, “they can’t be the same amount,” he is basing his judgment on a shape or in terms of a picture.

Adam knows the meaning of fractions. He can derive the numeric value that it is a $\frac{1}{2}$, but he says that they are not the same amount. He is basing his judgment about the amount on the picture, and not the numeric value.
Derek has the mathematical ability to derive a fraction from the picture, and he has the knowledge to understand numbers irrespective of the pictorial representatives afterwards.

Teaching a Law of Exponents: Teachers’ Understandings of Discourse-based Formative Assessment Practices (DAP)

Two classroom scenarios, where the teacher and students are working on exponents, were provided for teacher participants during the interview, and they were asked to think about the similarities and differences in each scenario. The scenarios were adapted from Lampert (1990) to fit the purposes of the interview. In both scenarios, the objective of the lesson is to teach a law of exponents that when two numbers with exponents that have the same base are multiplied, the base remains the same and the exponents can be added (i.e., $n^a \cdot n^b = n^{a+b}$). The first scenario is an illustration of “convergent assessment” exchange, while the second is representative of “divergent assessment” exchange (Pryor & Crossouard, 2008).

Below are the actual scenarios teachers were asked to read and interpret:

In the classroom scenarios below, the teacher and the students are working on exponents. Please read each scenario. Think about the similarities and differences in each.

**Classroom Scenario 1.**

Teacher: (She writes on the board: $7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7$). Arthur, how can I express this in exponent form?

Arthur: 7 to the 8th power.

Teacher: Good job, Arthur. The teacher writes on the board: $7^8 = 7^4 \times 7^4$. Ok, class. Look at this equation. What do you notice?
Gar: You broke 8 in half to get 2 fours.

Teacher: Excellent, Gar. $4 + 4 = 8$. So we can take the exponent of a base and break it up into its addends. We get an important law of exponents $(n^a)(n^b) = n^{a+b}$.

Teacher: Theresa, what if $n = 6$, $a = 2$ and $b = 3$? Come write it on the board.

Theresa: She writes: $(6^2)(6^3) = 6^{2+3}$.

Teacher: Can you simplify that?

Theresa: I substituted like you said …

Abdul: I know how to do it. It’s 6 to the 2nd power times 6 to the 3rd power equals 6 to the 5th power.

Teacher: Very good, Abdul. I’m going to write some more on the board for everyone to do.

The teacher goes to the board and begins to write the first of several problems:

$(5^3)(5^6) = 5^9$

**Classroom Scenario 2.**

Teacher: The teacher writes on the board: $7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7$. What power is this?

Arthur: 8th.

Teacher: That's $7^4$ squared. She writes on the board: $7^8 = 7^4 \times 7^4$

Teacher: What's $7^{16}$, Arthur?

Arthur: It's going to be $7^8 \times 7^8$.

Julio: I think $7^{16} \times 7^{16}$ is going to be $7^{32}$. It just doubles.

Soo Wo: Since $7^3$ is 343, I think $7^6$ would be $7^3 \times 7^3$, which would be 343 x 343.

Teacher: What do you think about $7^3 \times 7^2$?
Molly: That’s going to be the same as $7^5$.

Teacher: How do you know?

Molly: I already know that 7 cubed is 343 and 7 squared is 49. So $7^5$ is going to be $343 \times 49$.

Theresa: When you multiply the same bases, you can add the exponents. So $7^2 \times 7^3 = 7^5$.

Teacher: Is there a way to use symbols to represent what Theresa just said?

_The students start working on a symbolic representation._

After reading the scenarios, the following questions were asked:

1. What are your general impressions of the scenarios?
2. What is the teacher trying to get the students to learn in the scenarios?
3. What similarities and/or differences do you see between the two scenarios?
4. What do you think about the teacher’s approach in the first scenario?
5. What do you think about the teacher’s approach in the second scenario?
6. Do you think one approach is better than the other? Why?
7. Is there anything you would do differently? Why?
8. Which approach best characterizes how you teach? Please elaborate. (Please point to examples in the scenarios and in your own teaching that you think is similar or dissimilar.)
9. How frequently do you teach this way? When does your teaching depart from this? Why?

The first scenario represents convergent formative assessment, or the traditional approach to teaching and learning. In convergent formative assessment, teachers expect
students to acquire a specific procedure outlined by a textbook or agenda for them to appropriate. Students are expected to follow the instruction of the teacher or the textbook (Pryor & Crossouard, 2008). In the scenario, the teacher first introduces a law of exponents with symbols, and then has students practice it by substituting with concrete numbers.

The second scenario represents divergent formative assessment, or a social-constructivist approach to teaching and learning. In divergent formative assessment, teachers give students opportunities to demonstrate their current levels of understanding by having them explain, restate, or elaborate on their previous responses (Pryor & Crossouard, 2008). In the scenario, the teacher asks a question such as “What do you think about 7^3 x 7^2?” and a follow-up question such as “How do you know?” to probe student’s thinking. The questions are exploratory and open-ended. In contrast to the first scenario, the teacher in the second scenario first explores various concrete examples allowing enough time for students to formulate their ideas. Then, the teacher nudges students to develop abstract thinking by asking “Is there a way to use symbols to represent what Theresa just said?”

**Teachers’ Opinions about the First Convergent Approach**

In the first approach, the teacher presents the generalization of a law of exponents and has students solve similar problem by substitution (Teacher Yang and Teacher Koh). The teacher shows one example 7^8 = 7^4 x 7^4, tells the class that they can take the exponent of a base and break up into its addends, and draws the conclusion using symbolic representation n^a n^b = n^{a+b} (Teacher Ahn and Teacher Hwang). The approach is deriving a formula from one simple example and learning by substitution. The law of exponent was
introduced at the beginning of the class (Teacher Ryu). Some teachers said that the conclusion was derived rather too soon (Teacher Yang), that students would have difficulty understanding because the symbols were introduced too early, and that it would have been better if more concrete examples were presented before turning them into symbols (Teacher Hwang). Teacher Koh said that it is possible for students to acquire a lot of content in a short amount of time in this approach.

Teachers elaborated on their perspectives of the advantages and disadvantages of the first convergent approach. Teacher Kang said,

Since the formula was presented right away students can acquire the content easily, yet there is lack of time for students to reason mathematically. Because students are asked merely to substitute numbers into the formula, they are not provided enough time to reason how the formula was derived.

Teacher Seo’s statement resonates with what Teacher Kang said,

The generalization was derived rather too soon. Students could have noticed the pattern that the exponent of a base can be broken into its addends on their own. The examples were not many, and it doesn’t seem like the knowledge discovered by the students.

Teacher Jeon assessed thoroughly the advantages and disadvantages of the first convergent approach:

The teacher provides one concrete example, makes a generalization, and then teaches other examples. I think the lesson is leaning towards the transmission of knowledge. Through the one simple example, the teacher presents what was intended right away. There was little time for students to think. Because when the
teacher asked, “what if n=6, a=2, b=3? (how can it be applied?),” even though the student was able to apply the numbers into the formula, she answered, “I substituted (the numbers into the symbols) like you said,” not knowing what it meant. The advantage of this approach is that because students accept the knowledge without confusion, the application is quicker. The disadvantage is that it can limit student thinking. It is likely that students would consider mathematics as a ready-made knowledge. This approach might take away students’ interest in learning math, because they think they only have to accept things.

**Teachers’ Opinions about the Second Divergent Approach**

Whereas the first approach is deductive (formula and then examples), the second approach is inductive (from examples to formula). In the second approach, the teacher provides a lot of examples, helps students find patterns on their own, and guides them to induce generalization, an additive law of exponents (Teacher Koh, Teacher Kang, and Teacher Cho). For example, the teacher provides concrete examples such as $7^8=7^4\times7^4$, $7^{16}=7^8\times7^8$, $7^{32}=7^{16}\times7^{16}$, $7^{5}=7^3\times7^2$ so that students can use their prior knowledge to induce the additive law of exponents, and has students use symbols to represent what they learned (Teacher Ahn and Teacher Hwang). Teacher Ahn further said that students are encouraged to use their prior knowledge and are given sufficient time to experiment in various ways so that the law of exponent is introduced in a gradual manner.

Some teachers explained the benefits of this approach. First, students are given sufficient time to reason mathematically on how the formula can be derived (Teacher Kang). Second, the thought process will remain longer in students’ memory and students will become able to transfer this knowledge into other areas (Teacher Koh). Third,
Teacher Cho pointed out that this approach is ideal when the class period is longer, when the instructional content for teachers to cover is less, and when the number of students per class is smaller. Other teachers explained how the lesson could be improved. Teacher Yang said that if there were more examples using the base much smaller number such as two or three instead of seven, students could understand more easily about the law of exponents. Teacher Hwang said that the majority of examples provided are an expansion of doubles (8=4+4, 16=8+8, 32=16+16). If there were other examples such as 8=3+5 or 8=2+6, the lesson could be better.

Teacher Seo and Teacher Jeon thoroughly assessed the advantages and disadvantages of this second divergent approach. Teacher Seo said,

The class discussion transpires from the student answers. The teacher asks about student thinking frequently, gives opportunities for students to express their thinking, and encourages discussion among students. However, the lesson seems a little bit distracted. I see in the scenario, Arthur responds in one way, followed by Julio’s response in another way. It is okay if the students are following what others are saying 100 percent, but when the direction of the class discussion goes in ways that a student have not thought of, and if the teacher follows up on every students’ remarks, then one might feel that he/she is lost.

Teacher Jeon’s statement resonates with what Teacher Seo said:

The advantage of this instruction is that math is considered as students’ own construction. Students might approach math with joy. Since the teacher creates a safe environment for students to express their thoughts, students become active in learning math. However, when there are 40 students in a class, it becomes harder
for the teacher to proceed this way. For some students who did not master the previous content, it might be difficult for them to follow this kind of instruction. Other students might get confused and become unable to catch the gist of the lesson, while they are trying to comprehend everything about what others are saying in the class.

Teacher Seo and Teacher Jeon are making a very important point in their statements about the difference between conventional and reform-oriented classes and the differences among the reform-oriented classes. Wood, Williams, and McNeal (2006) noted that there are differences between conventional and reform-oriented classes, and among reform-oriented classes, in terms of social features and the quality of students’ thinking. Walshaw and Anthony (2008) emphasized that a pedagogical approach that can move students’ thinking forward involves much more than creating a safe climate for discussion and acceptance of other students’ differing ideas at face value. Teachers need to differentiate between responses and support students’ thinking.

First, teachers synthesize students’ contribution and differentiate between the mathematical integrity of students’ ideas. Second, they orchestrate mathematical discourse through careful questioning and purposeful interventions. Third, they intervene to redirect discussion to ensure that important mathematical ideas are being developed. (pp. 526-528)

**Teacher Beliefs and Practices**

There were teachers who were consistent in their beliefs and practices. For example, six teachers (Teacher Hwang, Teacher Yang, Teacher Koh, Teacher Kang, Teacher Ahn, and Teacher Ryu) expressed that the second divergent approach is better,
and that the same approach best characterizes how they teach. Three teachers (Teacher Shim, Teacher Choi, and Teacher Yoon) expressed that the first convergent approach is better, and that the same approach best characterizes how they teach.

There were teachers who showed mismatch between their beliefs and practices. For example, Teacher Cho thought the second approach is better for children, and yet uses both approaches case by case. She takes the first approach 60% of time when teaching algebra, when time is lacking, and when instructional tools are lacking. She takes the second approach 40% of the time teaching shapes or graphs, or teaching chapters that are handy in showing multimedia equipment. Teacher Jeon thought that the second approach is the direction toward which math education should be heading, yet feels that taking the second approach is a bit difficult in reality, because of time constraints, large number of students per class, and the difference in students’ achievement levels. She takes the middle approach. Teacher Seo thought that both approaches have their own good and bad aspects. She takes the first approach usually, but probes student thinking (second approach) when starting a new chapter. Table 9 summarizes teachers’ approaches to teaching.

Table 9

**Teachers’ Approaches to Teaching – Convergent/Divergent**

<table>
<thead>
<tr>
<th></th>
<th>Teachers (Years of teaching experience)</th>
<th>School Types</th>
<th>Do you think one approach is better than the other?</th>
<th>Which approach best characterizes how you teach?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle School</td>
<td>Teacher Ahn (20 Years)</td>
<td>Public</td>
<td>Second approach</td>
<td>Second approach</td>
</tr>
<tr>
<td></td>
<td>Teacher Yang (4 Years)</td>
<td>Public</td>
<td>Second approach</td>
<td>Second approach</td>
</tr>
<tr>
<td></td>
<td>Teacher Kang (8 Years)</td>
<td>Public</td>
<td>Second approach</td>
<td>Second approach</td>
</tr>
<tr>
<td>Teacher</td>
<td>(Years)</td>
<td>School Type</td>
<td>First Approach</td>
<td>Second Approach</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>-------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Teacher Shim</td>
<td>31</td>
<td>Public</td>
<td>First approach</td>
<td>First approach</td>
</tr>
<tr>
<td>Teacher Jeon</td>
<td>11</td>
<td>Public</td>
<td>Second approach</td>
<td>Middle approach</td>
</tr>
<tr>
<td>Teacher Ryu</td>
<td>15</td>
<td>Private</td>
<td>Second approach</td>
<td>Second approach</td>
</tr>
<tr>
<td>Teacher Cho</td>
<td>10</td>
<td>Private</td>
<td>Second approach</td>
<td>Both approaches (First approach 60%, Second approach 40%)</td>
</tr>
<tr>
<td>High School</td>
<td></td>
<td></td>
<td>Did not decide. (Each approach has good and bad.)</td>
<td>First approach (First approach usually, Second approach at the beginning of a chapter)</td>
</tr>
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<td>Teacher Koh</td>
<td>10</td>
<td>Public</td>
<td>Second approach</td>
<td>Second approach</td>
</tr>
<tr>
<td>Teacher Hwang</td>
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<td>Public, Special-purpose</td>
<td>Second approach</td>
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<td>Teacher Yoon</td>
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<td>Independent private</td>
<td>First approach</td>
<td>First approach</td>
</tr>
<tr>
<td>Teacher Choi</td>
<td>22</td>
<td>Independent private</td>
<td>First approach</td>
<td>First approach</td>
</tr>
</tbody>
</table>

**Teachers who prefer the second approach, and teach in the second approach.**

Six teachers (Teacher Hwang, Teacher Yang, Teacher Koh, Teacher Kang, Teacher Ahn, and Teacher Ryu) expressed that the second divergent approach is better, and that the same approach best characterizes how they teach. Teachers said that they preferred the second approach because students can derive generalizations themselves. Teacher Kang best explained this: “If teachers present the formula, it becomes mechanical problem solving involving simple substitution. I prefer the second approach because students are given opportunity to reason mathematically and become mathematicians themselves.”

Teachers said that they teach in the second approach. Teachers pointed to examples in the second scenario and in their own teaching that they thought was similar.
or dissimilar. Teacher Yang and Teacher Koh pointed to examples in the second scenario to illustrate how they taught differently. Teacher Yang said that she would take smaller base such as two or three.

\[
2^3 \times 2^2 = (2 \times 2 \times 2) \times (2 \times 2) = 2^5
\]

\[
3^3 \times 3^4 = (3 \times 3 \times 3) \times (3 \times 3 \times 3 \times 3) = 3^7
\]

In the first parenthesis two is multiplied three times and in the second two is multiplied two times. In total, two has been multiplied five times, which results in 2 to the power of 5. Teacher Yang acknowledged that when she taught this way students have quickly noticed the additive law of exponents.

Teacher Koh said that besides taking doubles or halves of the exponents, she would present various examples that when added would make the exponent eight such as (1, 7), (2, 6), and (3, 5). Teacher Koh also mentioned that she would take smaller bases as Teacher Yang.

\[
2^2 \times 2^3 = 4 \times 8 = 32 = 2^5
\]

\[
2^1 \times 2^1 = 4 = 2^2
\]

\[
2^1 \times 2^2 = 8 = 2^3
\]

Teacher Koh said, “I would list various examples in this way so that students can notice the pattern right away.”

Teacher Ahn and Teacher Ryu gave examples in their own teaching to illustrate how they taught similar to the second approach. Teacher Ahn said that even when students produce errors in problem solving, she allows them to experiment in their own ways by going through trial and errors.
For example, when I ask students to get the reciprocal of (-3), students sometimes answer 1/3 instead of the right answer (-1/3). The right solution process is as follows:

\[ x \times (-3) = 1 \]
\[ x \times (-3) \times (-1/3) = 1 \times (-1/3) \]
\[ x = (-1/3) \]

When students do not seem to understand the definition of reciprocal, I think it is worthwhile to allow students to multiply the equation by 1/3 and learn that it does not work by trial and error. When students are confused, I let them experiment as they wish and have them discover where they got wrong.

Teacher Ryu explained that she derives conclusion by showing various concrete examples. She said, “Middle school students tend to have difficulty when symbols are introduced. So I show them concrete numbers first, tell them that I will change it into symbols, and show them the formula in the last stage.” Teacher Ryu said that she tries hard to derive conclusion by having students experiment with concrete operations or with concrete tools, not only in algebra but also in geometry. She taught \( pi \) by having students measure the circumference and diameter of any circle objects such as a cup, lid of a bottle, or a pot. She also mentioned that because lab classroom is supported in her school for math, she could use manipulatives or instructional tools to derive that the volume of a corn is a third of the volume of a cylinder.

Teachers said that they try to teach in the second approach most of the time, but their teaching depart from this when they lack time to cover content.
Teacher Kang) and when students seem to have too much difficulty and teacher guidance is needed (Teacher Koh and Teacher Ahn).

**Teachers who showed mismatch between their beliefs and practices.** Three teachers (Teacher Cho, Teacher Jeon, and Teacher Seo) showed mismatch between their beliefs and practices. First, Teacher Cho expressed that the second approach is better because the depth of learning is much more deeper when students have come to realize the mathematical principles themselves. She tries to teach in the second approach about 40% of the time. Her teaching depart from the second approach because of the lack of time, and mostly because of the lack of instructional tools that she thinks is necessary for the kind of instruction that involves student thinking.

Second, Teacher Jeon expressed that the second approach is better, but takes the middle approach in her teaching. She would give more examples than in the first scenario, such as $7^0=7$, $7^1=7^2$, $7^1=7^3$, by changing just one exponent and then changing both exponents. Then she would have students find patterns and ask them how they can make generalization. She explained that this approach is neither presenting formula right away (first approach) nor having students create their own from scratch (second approach). Rather, she said she would show examples and create a framework in which students can make generalization under teacher guidance. Although she takes the middle approach, she thought the second approach is where math education should be headed. There were constraints, however, such as large number of students in each class and wide gap between students’ levels of understandings.

Third, Teacher Seo did not decide which approach was better. She taught in the first approach most of the time. For example, she asks students questions at the beginning
of the lesson, and then summarizes what has been learned on the board by using symbolic representations. She recalls that she did not ask questions, such as “Is there a way to use symbols to represent what Theresa just said?” presented in the second scenario, because the symbolic representations are already established in the textbook. She thinks that she might have limited ways of student expressions.

**Teachers who prefer the first approach, and teach in the first approach.**

Three teachers (Teacher Shim, Teacher Choi, and Teacher Yoon) expressed that the first convergent approach is better, and that the same approach best characterizes how they teach. Teachers preferred the first approach because students can accept mathematical concepts more easily. Teacher Shim said, “Students might be distanced from math when there is confusion. I think teachers must be prepared to explain major mathematical concepts at the beginning of the class so that students can understand more smoothly.”

Teachers taught in the first approach. Teacher Shim said,

I heavily emphasize the important conceptual parts. When students ask questions about content learned in the past, I do not simply throw the formula right away. Instead, I have my students recall ‘let’s think about how I explained and derived the formula.’ Even if it takes time at first, when I introduce a concept I use various tools (experiments, sculptures, or fruits) to explain the process so that students can easily recall later on.

**Discussion**

Duncan and Noonan (2007) describe assessment reform as characterized by “(a) the rise of large-scale assessment, and (b) changes in teachers’ classroom assessment practices” (p. 1). The researchers find that most provinces in Canada use provincial large-
scale assessment, and that the role of formative assessment is being promoted to make fundamental changes in classroom assessment practices. They acknowledge that teachers’ decision-making in assessment is influenced by external factors such as large-scale testing, internal policies, and classroom realities, and that teachers embrace some form of assessment reform while maintaining traditional practices.

Involving 513 teachers in 66 high schools in one Western Canadian province, Duncan and Noonan (2007) created a profile of assessment strategies and grading practices in high schools. They found that high school math teachers demonstrated lower use in reformed approach of assessments such as “observations, essay-type questions, projects, and student presentations” (pp. 11, 14), while preferred using more traditional assessment forms such as “quizzes, multiple-choice/objective tests, and major exams” (pp. 12, 14). They hinted at the idea that middle school teachers would be more focused on authentic assessments, because of possible curriculum difference between middle and high schools.

There was a possible difference between middle and high school teachers’ assessment practices from my dissertation data. In-depth interview data from Korean teachers indicate that two to three middle school teachers out of seven thought that the first approach (convergent) characterized their teaching, while three high school teachers out of five thought so. In other words, 22-43% (less than half) middle school teachers characterized their teaching as traditional, while 60% (more than half) high school teachers characterized their teaching as traditional. Although it is a little bit difficult to make such a generalization about the differences of middle and high school teachers’
assessment practices from a small number of teachers (n=12) involved in my dissertation study, I find it important to document this finding.
Chapter 6

Government Educational/Assessment Policy and Professional Development for Teachers

Morgan and Watson (2002) claim that assessment is interpretative in nature and examine teachers’ informal classroom assessment of students’ performance in the course of everyday teaching (Study A), and formal assessment of extended written mathematical tasks (Study B). In both studies, they assume that teachers assess “texts” produced by students. The text refers to “any verbal or nonverbal behavior taken by a teacher to indicate some form of mathematical attainment or a lack of attainment” (p. 84).

With in-service training, U. K. teachers are engaged in “(a) interpreting criteria, (b) grading student work, (c) engaged in agreement trial, in which teachers grade the same piece of work independently and then meet in order to achieve agreement, and (d) role-playing moderation procedures” (p. 87). This is similar to a Korean context, where teachers hold multiple grading committee meetings to reach an agreement for long-descriptive written assessment. Similar to Korea, U. K. teachers’ assessment practices are expected to conform to the national standards and are regularly inspected by government agencies.

Korean teachers believe that rich information can be pulled not from formal tests but from informal classroom observations. In Study A, however, the researchers and teachers had different opinions about a student, indicating that it is important to recognize the partial and interpretative nature of classroom observation. Then, it seems desirable to prevent such bias in informal assessment by making written work only source of evidence.
In Study B, teachers examine students’ written work in the General Certificate of Secondary Education (GCSE) examination. According to a 1988 reform of public examination in U. K., a component of coursework was introduced which can take up to 20% of GCSE, along with the traditional timed exam. Coursework takes the form of extended investigative tasks, can be completed in class and at home, and is assessed by one’s own teacher (p. 93). In contrast, the traditional timed exam is assessed by the external examiners. Study B looks at students’ written reports of coursework component, which is an extended investigative work for high-stakes GCSE assessment. Teachers were engaged in moderation process. It was found that teachers reached different judgments about the same student, and such major differences in teachers’ interpretations occurred when students’ text diverged from the norm. For a more improved assessment, Morgan and Watson address the importance of the role of professional dialogue, the moderation processes in which the teachers were engaged.

Similar to the coursework component of the GCSE examination in the U. K., Korean government enforced a new type of assessment in the paper-based tests of major exams (i.e., mid-terms and final exams). The newly implemented assessment is a long-descriptive-written form of assessment. Students are asked to write their solution strategies as well as their solutions on the answer sheets. In order to grade students’ written work, teachers prepare a scoring guide and a sample answer sheet in advance, grade samples of students’ work, hold multiple grading committee meetings with teachers in the math department for moderation process, and go through an appeal process with students. The major exams are now framed in a larger framework of the standards-based assessment, where students’ individual achievement/progress is deemed important rather
than focusing on the comparison among students. It is important to note that the teachers’ daily instruction is heavily influenced by these new forms of assessment.

The description I have provided is a short introduction of this chapter. Government education policy is important to discuss in my study, because it directly impacts teachers’ daily instruction and how teachers practice formative assessment. In addition, professional development programs address changes in education/assessment policies so that teachers in unit schools can be informed of the policies and work to adopt them successfully in their practice. First, the government education and assessment policies that impact teachers’ formative assessment practice will be discussed in this chapter. Then, teachers’ learning opportunities for formative assessment will be explored. Since formative assessment practices will be shaped by the larger system in which it is embedded including summative tests and accountability tests (Bennett, 2011), I will begin with Korean student grade management system.

**Student Grade Management System**

Similar to the U. K., at the beginning of the semester, Korean teachers in their own subject department hold grade management committee meetings (성적관리위원회 또는 교과협의회) to determine what percentage to allocate for paper-based assessment (지필평가) and for performance assessment (수행평가). Usually, schools allocate 70% for paper-based and 30% for performance assessment. In this case, 35% is assigned for the mid-term and other 35% for the final exam. Some schools allocate 80% for the paper-based and 20% for the performance assessment. The percentage of the paper-based and performance assessment is adjustable every year while teachers hold the grade management committee meeting.
Paper-Based Assessment

Paper-based assessment takes the form of schools’ regular exams such as mid-term (first-half term) and final (second-half term) exams. Among 100 points, 70 points are objective questions (객관식), or multiple-choice items (선다형), and more than 30 points are subjective questions (주관식 또는 서답형), questions that require short answer (단답형) or long descriptive answer (서술형). Short-answer questions should be included for more than 10 points, and long-descriptive-answer questions for more than 20 points. In accordance with curriculum reform movement, the percentage of long-descriptive-answer questions is increasing year by year. For instance, teachers were required to administer more than 10 points of long-descriptive-answer questions in year 2012 and more than 20 points the following year in year 2013.

Long-descriptive-written assessment (서술형평가) requires students to show their solution process on their answer sheet. According to Teacher Hwang, students solve a problem using various solution strategies, and it produces a wide range of different solution processes. Teachers have to anticipate these different paths to a solution in advance to grading student answers. They give partial credits for incomplete solutions. Teachers adjudicate how much students demonstrate their understanding and how much mathematical concepts are included in the solution process. The whole process can be interpreted as being subjective. Teachers report some difficulties grading long-descriptive assessment.

Uniquely, an independent private high school administers three regular exams – the first exam is same as mid-term exam, the second is 100% long-descriptive assessment, and the third is final exam. Teacher Choi, a teacher in the independent
private high school, said that besides mid-term and final exams, the school includes an additional exam that solely tests students’ abilities to answer long-descriptive questions. This shows how much schools take it seriously to prepare their students for a new form of assessment that is emerging.

**Performance Assessment**

Performance assessment (수행평가) can take two forms. Teacher Choi explained the two forms of performance assessment: “First, teachers accumulate notes/data that record observation of students’ performances in classroom activities. Second, it can be having students take tests that are similar to schools’ regular exams.” There are three categories teachers look for in performance assessment: attitude, assignments, and note-taking. Usually, teachers (Teacher Yang and Teacher Jeon) allocated 10 points for attitude and 20 points for assignments. Other teachers (Teacher Ryu) allocated 10 points for attitude, 10 points for assignments, and 10 points for note-taking.

Points for attitude include students’ levels of participation, student presentation, raising good student questions and responding to teacher solicitations.

Points for assignments include keeping notes of problems they solved incorrectly with revised solution processes (오답노트), solving exercise problems, and taking good note of the lesson. For example, Teacher Jeon assigns students supplemental problems (심화보충문제) for each lesson, exercise problems (연습문제) when small units are completed, and chapter evaluation problems (단원평가) when a whole chapter is completed. Moreover, Teacher Ryu adds appropriate assignments that are aligned well with the unit’s learning goals, such as having students create problems when learning a
unit on equations, and having students create a geometric figure with colored papers (confetti) or with millet stalks when learning a unit on geometric figures.

Taking notes of the lesson was considered important for Teacher Ryu. She reorganizes the textbook to create worksheets for students. The worksheet for a chapter is five to six pages long and it can be used for a month. She distributes the worksheet to students at the beginning of a chapter. The worksheet includes a summary of important lesson content of the chapter, theorems, lemmas, corollaries, and their proofs, along with necessary formulas to keep in mind. She left some important parts blank so that students can fill them in as they learn the chapter. She also included application problems that do not appear on the textbook but seem helpful, and problems that appear frequently on the high school entrance examination.

**Student Academic Report Cards**

Teacher Ahn, Teacher Koh, and Teacher Seo explained the process of how the scores on the student academic report cards are calculated and used in the admission process later. The record of paper-based and performance assessment is compiled to students’ academic report cards. All Year 3 middle school students and all high school students are ordered into nine rankings for each subject areas. The student’s relative position within the nine rankings influences the chances of getting admitted to universities and colleges. For Year 1 and Year 2 middle school students, the raw scores, average, and standard deviation for each subject area is provided but not the total aggregate sum of all subject areas. The students are not ranked in order and in relative comparison with each other. Rather, they are evaluated on whether they achieved a certain standard.
Government Educational and Assessment Policies

Government educational policies include (a) two-plus-one policy or three-plus-one policy, that is, combining students of two classes and dividing them into three classes, or combining students of three classes and dividing them into four classes (수준별이동수업), utilizing lab classroom for math subject (교과교실), (b) 2009 reform curricula (2009 개정교육과정), along with story-telling approach to teaching and learning (스토리텔링) and self-directed learning (자기주도적 학습), and (c) long-descriptive-written problems (서술형평가) and standards-based assessment (성취평가제), which is an assessment of student achievement against their position to an absolute standard rather than comparing student’s ranks against their peers.

The Korean government consistently seeks ways to improve the quality of public education (공교육내실화). According to Teacher Seo, the student academic report card is given more emphasis and its percentage towards college entrance has increased so that students are more inclined to commit to the system of public education. This allows teachers to have more authority in classrooms and have students’ attention for classroom activities. Moreover, from Teacher Cho’s interview, there is an emphasis on reducing the gap between high- and low-achieving students, while raising the standards so that all students can show more than ninety percent of mastery.

Two-Plus-One or Three-Plus-One Policy (수준별이동수업)

At the structural level, there is two-plus-one or three-plus-one policy, where students of two classes are combined and then divided into three classes, or students of three classes are combined and then divided into four classes (수준별 이동수업).
Teacher Ahn and Teacher Ryu elaborated on this policy. To enable this, the government committed intern teachers to each school to take care of extra classes created in the process. Initially, the schools took considerations of students’ grades and assigned them to one of the classes of three different levels, high-level, medium-level, and low-level classes. After parents’ complaints poured in, schools began to assign students to classrooms as they would normally do for classroom placement, not taking account of students’ grades.

Thus, it became more about reducing the number of students per each teacher than about grouping student with similar abilities. Since the number of students per each teacher was reduced substantially, teachers can give more in-depth attention to each student. They can observe students’ performances during instruction more in-depth way, such as examining students’ written work on the board or on their notebook, and listening to discussion among students. Students are given more opportunities to conduct presentations on the board and given more chances to be called upon to present their thoughts when they raise their hands.

**2009 Curriculum Reform (2009 개정교육과정)**

The 2009 curriculum reform (2009 개정교육과정) brought a significant change in the way of teaching and learning and the content of the textbook. Teacher Hwang said that the lessons were mostly lecture-based and teachers focused on the delivery of the content in the past. Now, with the influence of the 2009 reform curricula, students’ demonstration of their creativity and the development of a sense of self-autonomy are being heavily emphasized. The process of teaching and learning has shifted from the lecture-based to activity-oriented lessons. Through activity-oriented lessons, students can
become more familiar with math, and they are encouraged to acquire knowledge by being engaged in hands-on activities. Students can become more autonomous learners as opposed to being passive about the learning process.

Teacher Hwang described how the content of the textbook has changed significantly. In the past, a chapter of the textbook consisted of a short introduction in the beginning, the mathematical content in the middle, and exercises, end-of-unit problem sets, and end-of-chapter problem sets at the end. The 2009 reform curricula include introduction that is always related to real-world contexts to motivate students to learn the new chapter. Some related readings or episodes about mathematicians are included at the end of the unit or chapter.

Along with the 2009 curriculum reform, the story-telling approach to teaching and learning (스토리텔링) and self-directed learning (자기주도적학습) were introduced. The story-telling approach was introduced first in 2013 for Year 1 and Year 2 elementary-school students and Year 1 middle-school students. The main idea is for math teachers to teach math in relation to the real-world contexts. The textbooks reduced twenty percent of the mathematical content and instead included real-life contexts. For example, when I asked, “How has the 2009 curriculum reform affected your teaching” Teacher Ryu explained that she taught the concept of pi. She explained the concept by showing the ratio of the circumference of a circle to its diameter, using multimedia on how pi was discovered in the first place, introducing how it is used in the real world and the effects after pi’s discovery. She also used various real-life examples to teach the concept of similarity, by introducing the scales used in maps, explaining how ancient Egyptians might have calculated the heights of pyramids, and how the current ratio of
length and width of a letter-size paper became the most common paper size for office use. To introduce the concept of exponents, she engaged her students in folding newspapers.

The government supports lab classrooms for selected subjects such as math, science, and English (교과교실제). Math teachers can use a projector to show short video clips for students of how math is used in real life. The government’s intention in supporting the lab classrooms is to provide as many opportunities as possible for students to experience math in relation to their life and to teach them that math is not separate from their everyday lives.

Self-directed learning (자기주도적 학습) was also introduced along with the 2009 curriculum reform. Teachers are recommended to teach students to think autonomously and creatively. Rather than transmitting knowledge to students, teachers need to teach students to learn autonomously. Teacher Yang enacts self-directed learning by having students work in pairs as a mentor or a mentee, helping each other by discussing their own solution strategies. Moreover, when students are assigned to solve problem sets, they are required to write their solution process on their notebooks. Because the percentage of long-descriptive-answer problems in schools’ regular exams is increasing year after year, teachers emphasize that students should submit solution process as well as answers to the problems. Teacher Ryu emphasizes to students that they should demonstrate their ability to write solution process by themselves:

When I assign exercise problems as homework, if there is no solution process written on students’ notebooks, I don’t give them points for performance assessment. I tell my students that they have to become capable of writing
solution process on their own, because long-descriptive-written assessment is being emphasized.

**Government Assessment Policy**

Teachers addressed two government assessment policies: (a) standards-based assessment (성취평가제), and (b) long-descriptive-written type of assessment (서술형평가).

**Standards-Based Assessment (성취평가제)**

According to the Korea Institute for Curriculum and Evaluation (KICE), standards-based assessment (성취평가제) is an assessment of student achievement against their position to an absolute standard rather than comparison of student ranks against their peers. In the past, norm-referencing method (규준참조평가) was used to rank students within a bell-curve. Students who ranked within the top to 4% were given first rating, 4% to 7% a second rating, 7% to 12% a third rating, and so forth until the ninth rating. This kind of assessment is considered to generate severe competition, raise anxiety, and increase the level of stress a student can experience. It is pointed out that it is much more important for students to learn to collaborate and grow with each other. Criterion-referencing method (준거참조평가) was adopted to determine a student’s grade by comparing his/her achievement with clearly stated criteria for learning outcomes and clearly stated standards for particular levels of performance (Korea Institute for Curriculum and Evaluation, 2013).

Teachers decide on absolute standards (성취기준) and levels of performances (성취수준) for each standard, and give A, B, C, D, E letter grades. For example, Teacher
Jeon provided an example of an absolute standard and three levels of performances: “The standard is to learn the meaning of exponents and become able to compute operations of exponential forms. The high level of performance is that a student is able to express in exponential form engaging numbers with different bases. The medium level is that a student can express in exponential form engaging numbers with same bases. In the low level, a student knows the meaning of exponent and its base.” At the beginning of the year, teachers decide on the standards and levels of performances for each standard, develop examination questions (고사원안), and decide the levels of difficulties of each test items on the Bloom’s taxonomies (이원목적분류표).

**Long-Descriptive-Written Type of Assessment (서술형평가)**

The long-descriptive-written type of assessment (서술형평가) was introduced first in 2012, and the percentage of it in schools’ regular exams (mid-term and final) has increased from 10% in 2012 to 20% in 2013. For paper-based assessments (지필평가), 70 points are assigned to objective questions (객관식), or multiple-choice items (선다형), and 30 points are assigned to subjective questions (주관식 또는 서답형) of which 10 points assigned to short-answer questions (단답형) and 20 points to long-descriptive-written questions (서술형). In the past, almost 90 points were assigned to multiple-choice items and only 10 points were left for subjective questions. Even so, the subjective questions were all short-answer type that looked for a single numeric number for its answer.

The long-descriptive-written type of assessment (서술형평가) is an assessment that when a problem is given, students are required to show the process that leads them to
a solution. When I asked, “What do you think is the government’s intention to promote long-descriptive-written type of assessment,” Teacher Seo explained that she thought the intention is to get beyond the product-oriented assessment toward the process-oriented assessment, which assesses students’ learning process making clear whether they achieved the mastery. The intention is to make the unseen process visible: (a) How do students solve the problem; (b) what methods/strategies do they use to solve the problem; (c) is the strategy students are using an appropriate one; (d) how does the student describe the process; and (e) is the description written in a logical fashion?

The whole process is to make sure that the student is using appropriate strategy not merely generating a correct answer. Students are given full credit when they provide both the solution process and the answer. If they put answer only, then they are given a small partial credit. The solution process has received heavy emphasis, and it has become a regular routine that the teachers instruct how to write the solution process during their regular lessons.

Teacher Ahn explained that the long-descriptive-written problem usually starts with verbs such as “describe (서술하시요),” or “write” the solution process (풀이과정을 쓰시요). For example, when I asked Teacher Cho to provide an actual example of long-descriptive-written problem and explain how she grades it, she gave the following example: “Describe the process by which you solve a system of two equations. Then the students have to read the problem, come up with the equations, follow steps to solve the equations, and write the solution with a unit that reflects the problem situation. I give partial credit when core mathematical sentence that is necessary in each step is written. Among 10 points in total, coming up with equations can be given 3 points,
applying quadratic formula to solve the equations can be given 3 points, deriving correct roots can be given 2 points, and adding a unit that is well-aligned with the problem situation can be given 2 points.”

For more accurate understanding of the new assessment policy, various examples of the long-descriptive-written assessment are posted in the Korean Institute for Curriculum and Evaluation (KICE) website (http://seosul.kice.re.kr/index.do). An example from the chapter on exponents and logarithms will be introduced here. The level is for the first year of high school students. The evaluation component is the properties of exponents. The absolute standard in this problem is that the students can solve the problem by using the properties of exponents. The problem is as follows: Describe the process how you solve \(27x^3 + 81x\) when \(x = 3^{1/3} - 3^{-1/3}\). The scoring guidelines are as follows: Students are given five points when they have derived the correct value by cubing \(x = 3^{1/3} - 3^{-1/3}\) to the third power. Students are given three points when they have directly substituted \(x\) to the given expression, not using the property of exponents, and got correct value. Students are given three points when they have tried cubing \(x = 3^{1/3} - 3^{-1/3}\) to the third power, but did not get correct value. Students are given two points when they have directly substituted \(x\) to the given expression, not using the property of exponents, but did not get correct value (Korea Institute for Curriculum and Evaluation, 2014).

The good news is that teachers can catch right away where students got something wrong. Whereas students calculated roughly in their head in the past, now they have to learn to write their thought process logically, learn to summarize what is in their mind, and learn to write mathematical symbols and sentences. The difficult part is that there are so many different student answers teachers have to evaluate.
Teachers develop scoring guidelines (채점기준), anticipate how they would give credits for each step, and anticipate possible student answers (예상답안) and similar solutions (유사답) in advance. However, there are so many different student solutions that teachers are experiencing difficulties grading student answer sheets in a fair way in applying same standard for everyone. The teachers in math department hold a grading committee meetings (교사협의회) several times to agree on how to handle a certain type of solution, how many points to give to a specific answer, and so on. Even after this, they still confront different scenarios. If a teacher gives this student credit, then he/she has to give credit to another student using a similar strategy. The teachers revise their scoring guidelines several times while they hold multiple grading committee meetings. There are some instances that teachers themselves cannot come to an agreement through discussion. Students and parents as well raise complaints about their grades. The whole process should be predicated on faith in teachers’ clinical judgment and their professional knowledge about the subject.

**Policy Regarding High School Entrance**

There are high schools whose student selection process begins earlier than that of regular schools. These schools are special-purpose high schools focusing on science and math and focusing on foreign language, independent private high schools, Meister high schools (a type of specialized vocational high school), and vocational high schools. The comprehensive high school entrance examination still predominantly existing in the province does not influence students’ admission to these schools.

Special-purpose high schools focusing on science and math (과학고등학교) select students by administering school’s own entrance exam, requiring letters of
recommendations, and interviewing students. The teachers of special-purpose high school sometimes visit middle schools to see how the student candidate is performing and to ask middle school teachers about the student candidate’s school life. The Ministry of Education, Science, and Technology (MEST, 교육과학기술부) turned some special-purpose high schools focusing on science and math into gifted science and math high schools (과학영재학교). Year 1 and Year 2 middle school students are eligible to apply for the gifted math and science high schools and excused to graduate middle school early by the Gifted Education Promotion Law (영재교육진흥법).

The independent private high schools (자율형사립고등학교) give application qualification to students whose scores on their academic report cards are located in the upper half. Some schools select students within the province, while other schools select students from across the country. The application documents include students’ academic report cards, statement of purpose, letters of recommendation from the homeroom teacher or from the subject-specific teacher. Then the students interview. In the past, the interview asked for students’ knowledge of selected subjects such as Korean language, English, and math. However, the Ministry of Education prohibits these kinds of interviews that ask subject-specific knowledge, because it increases the students’ reliance on shadow education and burdens students. Rather than asking for students’ knowledge in subject areas, the interview now asks for students’ strategies of self-directed learning (자기주도전형), students’ experience in comprehensive reading (독서면접), and students’ orientation to human nature (인성면접).
Meister high schools (마이스터고등학교) are a specialized vocational high school. They were called mechanical technical high school (기계공업고등학교) previously and changed the name after the schools began to receive government support from waiver of tuition to free lunch. The schools are affiliated with industrial companies and provide vocational education. The affiliated company hires the graduates from Meister high schools, since they know that the students have already acquired skills necessary to work in the companies. It is beneficial for both parties: The students secure jobs right after their graduation, and the companies do not have to re-educate their staffs. More and more students choose to enter Meister high schools even when they are eligible to enter the regular high schools because of these foreseen benefits. The application document includes students’ academic report cards. Students have to interview as well. Other regular vocational high schools include mechanical technical high schools (기계공업고등학교) and commercial high schools (상업고등학교).

The above described high schools select students earlier. Because top-tier students go to the above four types of high schools (special-purpose high school focusing on science and math, gifted science and math high schools, independent private high schools, and Meister high schools) for more challenging educational opportunities, regular high schools lose their top-tier students year by year. The government is looking for measures to reanimate/strengthen the competitiveness of regular high schools.

All students graduating middle schools intending to enter regular high schools have to take comprehensive high school entrance examination (연합고사). The scores of student academic report cards (내신성적) are worth 70 points, and the scores of high school entrance exam (연합고사성적) are worth 180 points, together 250 points. The
components of student academic report cards include scores on schools regular exams such as mid-term and final exams, attendance, hours spent on volunteer experiences, and any rewards students earned. The comprehensive high school entrance exam consists of mostly objective multiple-choice items and small numbers of subjective items, which are all short-answer items. If students wish to enter regular high schools in the city area, they have to get high score on the high school entrance exam. If the student does not pass the cutline, they are allocated to regular high schools in the countryside.

Since the high school entrance exam covers all contents from Year 1 – Year 3, the teachers teach to the degree possible for students to have full knowledge of all contents from Year 1 to Year 3 in the middle school. Because one most important goal for middle school students is to enter high schools with high scores in entrance exam, the lessons taught in Year 3 middle school is heavily affected by these circumstances. That is, the lessons for Year 3 middle school students are mostly applying previously acquired knowledge to solve multiple-choice items efficiently in the given amount of time. They have little time for building up on the conceptual understanding. Teachers said that school lessons cannot be changed if the assessment is not changed (Teacher Jeon) and that teaching has to follow the admission system (Teacher Cho).

**Policy Regarding College Entrance**

Teacher Seo explained in-depth about the new policy for college entrance examination. The A/B selectable levels were newly introduced to the College Scholastic Ability Test (CSAT) in 2013. For math, the A/B options have been available for quite some time, while for Korean language and English the A/B options were administered newly in 2013. The difficulty level of questions in option A is easier than the previous
CSAT, and that of option B is similar to CSAT in the previous year. This new policy for college entrance examination raised some backlash and side effects in many levels. Students were confused which options to choose, and universities offered different student selection criteria.

When I asked “how the new college entrance examination policy impacts her teaching,” Teacher Seo said that teachers generally guide students on math/science track to take option B, and students on language arts/social studies to take option A. Those who are not performing well on math/science track are suggested to take option A, so that they do not give up on any easier problems. Year 3 high school students already have mastered all content for high school, and their lessons are geared toward preparation for CSAT. The level of difficulty is increasing year after year, because test developers intend to differentiate among the top-tier (well-performing) students. When I asked how many questions are devoted to differentiate the top-tier students, she said that the questions are either worth 2 points (low-level questions), 3 points (medium-level), or 4 points (high-level). There are about six to seven 4-point items, which take up 20 percent of the whole math test. These 4-point items are used to cream the top-tier students.

Because the main goal for high school students is to take CSAT and enter universities, the instruction reflects those needs. That is, the instruction is geared toward preparing students to get high score on CSAT. The math/science track has two textbooks that have to be covered in Year 2, and two other textbooks to be covered in Year 3. In reality, high schools cover all four textbooks in Year 2 in advance, and prep students for mock-tests and CSAT in Year 3. To prevent teaching all four textbooks in Year 2 intensely, the Office of Education in the province collects examination questions.
and monitors whether schools are engaged in prior learning (선행학습).

Although it is a rapid pace and students feel burdened by the amount of learning they have to do within a year, it is an inevitable circumstance in the long run.

While Year 2 high school students are burdened by a heavy load of curriculum, Year 3 students feel pressured for prepping for CSAT problems. The government’s resolution is to make CSAT questions closely connected with the Educational Broadcasting System (EBS). The government tells students that they have the capacity to take CSAT if they learn the materials in EBS textbooks. EBS also offers free Internet lectures. There are four books of EBS-CSAT Lecture (EBS 수능특강) and four books of EBS-CSAT Complete (EBS 수능완성). These books are connected to CSAT problems, so there is a strong tendency for Year 3 high school students to review the eight EBS books at minimum. Besides EBS books connected with CSAT (EBS 수능연계), there are four books of CSAT N-Jae (수능 N 제) and four books CSAT final mock-test workbooks (수능파이널 모의고사 문제집). In addition, there are workbooks similar to EBS books that are developed by other textbook publishers. All high school curricula are taught in Year 1 and Year 2. In Year 3, lectures are given based on EBS books and are focused on preparing students for CSAT.

In special-purpose high schools focused on math and science, most students graduate early in their second year and enter universities. Since these students have to submit application materials in the fall semester of Year 2, all high school curricula have to be taught and learned in three semesters in Year 1 and spring semester of Year 2. Lectures for Year 2 students are focused on math and science subject-specific interviews (심층면접) and occasional student recruitment (수시모집). These are not related to
CSAT. Lectures for Year 3 students are focused on CSAT, and EBS books are used as well in the specialized high school.

**Prior Learning / Shadow Education**

Teachers acknowledge that 70 – 80% of middle and high school students are receiving shadow education. The main goal of shadow education is to get high scores in the public education system, in the high school entrance examination, and in the college entrance examination. Teachers agreed that the role of shadow education should be limited to get help on what was not understood in schools, or to go deeper into what was learned in schools such as solving higher-level problems. Shadow education should be limited to reviewing what was learned in schools to complement public education and not the other way around. However, in reality, most private institutions are engaged in prior learning; that is, teaching content a semester earlier at minimum or a year or two earlier, leading to “the collapse of public education” (공교육붕괴).

The good aspect of shadow education is that it helps students learn otherwise left alone on their own devices. Students who are having difficulty understanding what was taught in school can get an opportunity to ask those one-on-one and supplement school work individually. Students who have the ability to learn more can get additional resources through shadow education. Teacher Jeon said,

I give lessons based on an expectation that my students do have a certain level of understanding. Students have to understand the low-level concepts, exercise to be able to ‘internalize’ the content, and achieve mastery. So, if private institutions can help students with those areas—low-level concepts, exercise problems, and mastery, it would be helpful for students to participate in my class.
The negative influences of shadow education on public education are multi-fold. First, because students already have learned in private institutions what will be taught in schools, they do not participate as actively as they might have if they were taught the concept for the first time. Teacher Ahn gave examples of such instances,

Some students are bored because they have mastered the concepts. Others mistakenly think that they know the concept because they have heard it before, even though they do not fully understand. Still others have become accustomed to the types of problems not having built the fundamental conceptual understanding. Teacher Yang explained,

Private institutions are mostly prior learning. Students come to schools having learned everything. They are one chapter ahead or even a semester ahead of the schedule. They have to listen to what is taught in school, but are engaged in other things because they know already having learned in private institutions. When I see these happening in my classes, I hope that they would listen to what I teach, instead of going to the private institutions.

Second, shadow education widens the achievement gap between the students who have had shadow education and students who have not. Students who come to class already having learned the lesson content through shadow education get good grades, but show lack of concentration in school’s lesson. Students who do not get shadow education wonder why their peers seem to understand more quickly while they have difficulty understanding. These students feel a sense of inferiority and tend to give up.

Third, students lose the ability to study on their own because of heavy reliance on shadow education. Teacher Koh elaborated on this point:
There is little time left for them to study on their own, because in school the teacher teaches and in private institutions the *hagwon* teacher demonstrates the skills of problem solving. The most desirable situation is that students take their own time to study difficult concepts and problems repeatedly by themselves. Students lack the time to think on their own, lack the ability to expand on their own thinking, and become incompetent around problems that require high-level thinking.

Fourth, the main goal of shadow education is to raise scores. Instead of focusing on building robust conceptual understanding, private institutions focus on getting the correct answer quickly by applying numbers to formulas. Students are interested in getting the correct answer and miss important things such as where it went wrong in the process, or what thoughts they are missing in the part. Students are engaged in meaningless calculation. For instance, Teacher Jeon observed in her classroom that when her students are asked to get the area of a circle with a radius of 3 centimeters, students write as follows: $3 \times 3 = 9\pi$, instead of writing fully as: $\pi r^2 = \pi \times 3 \times 3 = 9\pi$. In a similar way, when students are asked to get the surface area of a cone with lateral surface area $15\pi$ and base surface area $9\pi$, students write as: $15 + 9 = 24\pi$, instead of writing fully as: $15\pi + 9\pi = 24\pi$.

Fifth, there is a fundamental difference in how math is taught in schools and in private institutions. Private institutions present formulas and solve the problems not necessarily having explained how and why the formula was derived. Schools try to explain the conceptual background. Teacher Ryu explained,
Because math problems at middle-school level can easily be solved by applying appropriate numbers in formulas, students do not attempt to listen to the conceptual background as to how the formula can be derived. This can lead them being not able to solve problems at higher level. They should be engaged in learning conceptual understanding to be able to get a clue on how to solve high-level problems.

Teacher Ryu continued, “I think it is helpful for students to solve as many high-level problems as possible on their own that are aligned with their own grade level.”

Teacher Seo and Teacher Choi said that the public education tries to teach how mathematical theorems, corollaries, lemmas have been created, to teach that people’s logical thinking produced these ideas, and to share these processes with students. Teacher Seo explained,

Public education tries to tell stories sequentially. I think in public education teachers try to teach conceptual parts allowing some time to appreciate it. Not just stating the concepts, but starting from how the concept came about, and so on, very smoothly, introducing the history of mathematics.

When I asked what she meant by teaching a math concept with respect to math history, Teacher Seo gave an example of how she teaches a nonzero number raised to the power of zero is defined as one: “Defining exponents, defining a nonzero number to the power of zero, it was not a set rule. People were engaged in the process of defining it. So I introduce those processes so that students can get a sense of it.”
Responding to Government Educational and Assessment Policies

Government educational and assessment policies come down from the Ministry of Education to the Province’s Office of Education to the school’s assessment policy. Teachers in public education system have an obligation to conform to assessment policies as a civil service worker. The government provides professional development programs when there are changes to educational and assessment policies. Well- or ill-prepared, teachers conform to the changes in educational and assessment policies.

Teacher Ryu explained that,

I think education policy is moving towards providing students opportunities to embrace various mathematical thinking. The new policy is being delivered and there are changes being made to the newly adopted policy. I am transitioning into new phase along with the changes that are happening around the school system. The new approaches to teaching and learning were not as it was as it is today. But because educational policy is promoting new approaches to teaching and learning, and because younger generation students are coming to my class having received those newer kind of instruction, I feel that I should be ready to teach these students. I try to get necessary professional development programs.

Teacher Koh said that whenever there are changes in curriculum, teachers have to prepare teaching mostly by themselves. She observed that the professional development programs or useful resources become available to teachers one or two years after the new policy has been administered. She hopes that teacher education takes place before any new policy be administered in her workplace. There are a few professional development programs delivered but not enough programs become available to teachers. Some
teachers travel long hours to Seoul, capital city of South Korea, to receive necessary education for adjusting to new policy. Other teachers mostly learn to adapt by themselves. Teacher Koh said that if there are enough professional development programs and resources that become available for teachers, teachers will develop more capacity to adapt to the curricular reform or changes in textbooks.

**Professional Development for Teachers**

**Structure of Professional Development Programs**

The Ministry of Education (MOE) manages professional development programs. Their goal is to provide qualification training (자격연수) and job training (직무연수) to strengthen the professionalism of teachers, which will lead to the competitiveness of public education. Teacher professional development can be divided into two areas: those that are based on institutes that provide professional development (연수기관중심) and those that are based on school units (단위학교중심) (Korean Ministry of Education, 2012).

Professional development institutes (연수기관) manage three parts: (a) qualification training (자격연수) for teachers to become a principal, assistant principal, or to get level 1 teacher certificate, (b) job training (직무연수) for teachers to take courses that are beneficial to increase their job performance, and (c) special training (특별연수) for teachers who wish to study abroad to pursue higher degrees (Korean Ministry of Education, 2012).

The school units (단위학교) are in charge of carrying out research lessons (연구수업), holding research group meetings among subject departments.
having a teacher who participated in professional development programs at larger institute deliver the training for teachers in his/her own school (전달연수), videotaping own lesson for research purpose (자기장학), and inviting other teachers to his/her own classroom to observe the lesson and make suggestions through pre-conference and post-conference (동료장학) (Korean Ministry of Education, 2012).

The professional development institutes include central unit institutes (중앙단위연수원) such as the National Education Training Institute (중앙교육연수원) run by the Ministry of Education, training institutes run by capital cities or provinces (시도교육연수원), training institutes located at Universities of Education, or large universities that have School of Education (대학부설교육연수원), and distance education training institutes (원격교육연수원) (Korean Ministry of Education, 2012). Table 10 summarizes the structure and types of professional development programs.

Table 10

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<th>Type of Professional Development Programs (Korean Ministry of Education, 2012, p. 2)</th>
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<td><strong>Type of Professional Development</strong></td>
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<td>Professional Development Institutes</td>
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<td>(a) Qualification training – to become a principal, assistant principal, or to get level 1 teacher certificate</td>
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<td>(b) Job training – to increase job performance</td>
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<td>(c) Special training – for teachers to study abroad to pursue higher degrees</td>
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<td>School Units</td>
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<td>(e) Research group meetings among subject departments</td>
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<td>(f) Deliver training – teachers who participated in large professional development programs to deliver training for teachers in his/her own schools</td>
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<td>(g) Videotaping own lessons for research purpose</td>
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<td>(h) Invite teachers to observe lessons (pre-conference, observe lesson, and post-conference)</td>
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There is a special training for teachers who passed the teacher employment examination (임용시험 합격하면 받는 연수). It lasts for three weeks for all newly employed teachers gather, regardless of their subject areas. The supervisors, authorities on selected areas, professors, and teaching practitioners are invited to give lectures to the new teachers. The lectures are about how to teach students and what qualities or virtues a teacher needs to possess to become a good teacher.

There is qualification training (자격연수) on level 1 teacher certificate (일급정교사 자격연수). Teachers receive level 2 teacher certificate when they graduate College of Education. After three years of teaching experience at a public school, they become qualified to enroll to the qualification training on level 1 teacher certificate. After they successfully complete the training, for three to four weeks on summer vacation, they are promoted to level 1. The lectures are mostly about teaching mathematics, such as, how to motivate students to learn math and how to incorporate multimedia equipment to teach math. Teacher Yang recollected that it was meaningful to have an opportunity to discuss things with math teachers from other schools:

At the workplace it is rare to have deep conversation with other teachers about math. Here at the qualification training, I met with many math teachers working at different schools, and we were asked to discuss things like how to deal with students who are underachieving in math subject. The teachers raised the difficulties they are experiencing at their own school, provided suggestions how they dealt with these students, and discussed what to do when students struggle with math.
The job training (직무연수) are held during summer and winter vacations where teachers gather collectively (집합연수). It is also delivered through distance education online at anytime at individual teacher’s convenience, during semester or during vacations (원격연수). The forms of job training can be held in two ways: collective job training (집합연수) or individual online job training (원격연수). Both are legitimate, while online job training is gaining popularity year by year because of its convenience. Teacher Seo said that,

The instructors are mostly teaching practitioners. They are the ones who are familiar with what teachers do at classrooms. Teaching practitioners, neither principals nor assistant principals, are our peers and they introduce us to new teaching methods that they tried and tested in their own classrooms. These are very helpful actually in these regards.

There are various courses for the job training: courses for one credit, two credits, three credits, and four credits. One credit is worth fifteen hours. Teachers are recommended to take at least four credits, that is, sixty hours per year. The record of teachers’ participation in job training is important when schools are being evaluated.

The Office of Education at the province level (도교육청) or at the city level (시교육청) also provides important professional development opportunities for local teachers. The staff at the Office of Education survey local teachers to find what kinds of professional development experiences they need and offer courses on such areas. For instance, if the Office of Education at the province level offers training for long-descriptive-answer assessment, all math teachers representing each school gather at the site and learn how to incorporate the new assessment policy into their own teaching. The
representative teachers have to come back to their own schools, and deliver training for teachers in math department at each school. The training at the local Office of Education is convenient distance wise, but teachers are obligated to follow what was delivered to them through the training.

The province’s secondary math teachers’ research association (중등수학연구회) holds council once a year, in collaboration with the Office of Education at province level. They deliver what will be changing in the following year about math education in general, assessment policy, and educational policy. The teaching practitioners make a couple of presentations about the actual implementation of new policy in their own classrooms. The association also supports workshops for about two to three hours once a year. All secondary math teachers in the province gather once a year to share research around math subject. The research is focused on math itself, rather than for teaching math. For instance, Teacher Ahn mentioned that “it was about math curriculum, the relationship between CSAT and regular math exams in schools, and any topics related to math.”

At the school level, every school holds a meeting at the end of semester to reflect on things that went well, that need improvements, and steps to make adjustments for the following semester (한학기 실적반성회). All teachers in all subject areas gather to reflect about the school duties, their own subjects, and their experiences as a homeroom teacher. They discuss how the semester plan has been shaped, what the benefits of having the plans were, and what areas need improvements. Teacher Ahn said that “we discuss things like, these are the good points that we would need to pursue again next semester, and these are the parts where we need to make adjustments next semester because it did not work out the way it is this semester.” The teachers in the same department gather and
discuss first, after which all teachers in all subject areas come together and make presentations for their reflections.

Some enthusiastic teachers further participate in the Korean Society of Teachers of Mathematics (사단법인 전국수학교사모임). It started as a private organization, established by math teachers who shared the same vision. Now it is approved by the Office of Education as a legitimate teacher training institute. They hold a math festival, which is a math camp, once a year for three consecutive days at local universities. The locations are different every year. The teachers listen to collective lectures or select lectures from a list of agenda that interests them.

Contents of Professional Development Programs

There are various ranges of contents that are offered in professional development programs. First, there are programs specifically related to math teaching, such as, how to run classrooms specifically designed for math (수학교과교실 운영), how to increase the capacity of math teachers (수학교사역량강화), and how to incorporate math-related computer programming (Geometer’s Sketchpad or GeoGebra) into math teaching. Second, there are programs that are pertinent to all subject areas, such as, duties as a homeroom teacher (담임업무), academic and career counseling (진로지도), guidance on school life (생활지도), nurturance of good human nature (인성지도), and reduction of school bullying (학교폭력). Third, there are programs for teachers to pursue hobbies or sports.

The supervisors organize the programs and invite lecturers for the programs. Teachers participate in these programs to bring up variety of issues they are experiencing in their classrooms for discussion. Teachers develop bonding relations with their peer
counterparts, and listen to the senior teachers for various new methods of teaching strategies to be incorporated in their own classrooms. The teachers agreed that there are professional development programs about assessments in general, but they have not seen any courses that are offered specifically focused on formative assessment. I pursued areas that are highly related to and affecting teachers’ formative assessment practices. These are (a) long-descriptive-answer assessments (서술형평가), (b) standards-based assessment, assessment of student achievement against their position to an absolute standard rather than comparing student’s ranks against their peers (성취평가제), and (c) classrooms specifically designed for math (수학교과교실).

**Training for Long-Descriptive-Written Assessment**

Training for a long-descriptive-written assessment was described by Teacher Jeon, Teacher Shim, and Teacher Yang. When a new assessment policy is introduced, teachers receive training on the purpose/background, definition, and ways to apply it to their own practice. According to Teacher Jeon, the purpose and background of introducing long-descriptive-answer assessment is,

> Individuals are important, and everyone should become a person capable of higher-order thinking. To produce such individuals, it is not the best to have them pick an answer from a multiple-choice question. Now students have to develop a capacity to reason autonomously and to express it in an understandable way. So, long-descriptive-written assessment is important in these regards.

According to Teacher Jeon, teachers are introduced how to develop test items for long-descriptive-written assessment. The absolute standards (성취기준) and levels of performances (성취수준) in the standards-based assessment (성취평가제) should be
taken into consideration in the process of developing test items. Teachers are given instructions on choosing content and problem situation, conveying what students are expected to do with clear language, and attending to several things when developing test items. Then, they are given time to be engaged in actual writing of the test items. Finally, they are given instruction on how to develop scoring guidelines and how to give partial credits. Teachers select samples of students’ answer sheets, grade the samples with the initial scoring guidelines, and revise the scoring guidelines. They are informed of the types of grading errors and the reason why the errors arise.

Teacher Shim told another side of the training experience:

It comes down from the Province’s Office of Education as a guideline, things that we are asked to follow. School administrators, teachers in charge of assessments, director of research from all schools in the province gather in a place and get training. Teachers are provided samples of student answer sheets, and are asked how they would grade the samples. It happens that Teacher A scored this way while Teacher B scored higher. The teachers who attended the training come back to their own schools, pass down (deliver) the training to the teachers in his/her school, and instruct them. That way, it gets spread out. Otherwise, the teachers who did not attend the session cannot have a way to implement it. So somebody has to go attend the training and deliver it to their own schools.

Teacher Shim discussed how it can be applied to an individual school:

By holding the departmental committee meetings we discuss how it can be applied to our practice, what were the good precedents, what parts were helpful when we did trials, then how should we implement it in our school. We hold
meetings to discuss how best to apply it to our school taking into account the school’s own circumstances.

Teacher Shim voiced the importance of the role of unit schools in implementing new assessment policy:

The most important thing is how the unit schools actively seek ways to implement it. The Ministry of Education or the Office of Education at the Province- or city-levels, they try to promote/spread the new assessment policy, but the remaining parts have to be acted upon by teachers at the unit schools. Even though they offer/pass down good things from above, if the unit schools do not respond, it does not happen. So, the teaching practitioners have to be engaged in research and apply it actively.

**Training for Standards-Based Assessment**

Training for standards-based assessment was described by Teacher Ahn, Teacher Jeon, and Teacher Ryu. Teachers are introduced to why they should implement standards-based assessment, what is the definition, and how can it be implemented in actual practice. The two core concepts in the standards-based assessment are absolute standards (성취기준) and the levels of performances (성취수준) for each standard. In Teacher Jeon’s understanding, an absolute standard is similar to the concept of a learning objective, and the levels of performances are the levels of references how much students have achieved the learning objectives.

Teacher Jeon described the background/purpose why standards-based assessment is promoted to be implemented:
In 20 years or so, the number of students in each classroom will be significantly reduced. At that time, there should be a system administered that satisfies each individual student’s needs. A focus on individual student’s performance is gaining more potency. Instead of comparing students’ rankings against each other, it is becoming more important to capture how much an individual student achieved a learning target.

The definition of standards-based assessment is described well by Teacher Ahn. Teacher Ahn said that she received training about standards-based assessment when there was unsettled understanding about it, in 2012 and 2013, from a representative teacher who received direct training at the Office of Education. She understood that there is a shift from a relative evaluation to an absolute evaluation. In the relative evaluation paradigm, students were compared with one another by placing them in a rank order within a bell curve. In the absolute evaluation paradigm, teachers are asked to decide the absolute standards and the levels of performance.

Teacher Ahn further discussed how it could be applied in her practice. In schools that have a large number of high performing students, teachers set relatively high standards. In schools that have a large number of low performing students, teachers set rather low standards. Teachers then assess the levels of student performance accordingly. Teacher Jeon and Teacher Ryu acknowledged that standards-based assessment and long-descriptive-written assessment are being promoted together. Teachers develop test items according to the standards of the standards-based assessment, and consider the levels of performances.
Third, the lab classrooms, specially designed for math subject, were described by Teacher Cho and Teacher Ryu. Teacher Ryu explained that there are special lab classrooms that are equipped with whiteboards on all four walls of the classroom, where the teacher gives lesson in front and students get to write their solution strategies on the remaining three sides of the wall. In the middle school where Teacher Cho teaches, the classrooms for science and English subjects became equipped as lab classrooms. Teacher Cho went to training to be prepared how she would operate the lab classroom efficiently when her math classroom becomes a lab classroom.

Finally, Teacher Ryu mentioned that she received training on teacher questioning. She learned several things: “(a) Ask questions that enable students become engaged in divergent thinking, (b) allow wait time when asking and soliciting student answers, and (c) ask questions that emphasize the process of logical thinking rather than on the result.”

**Structure and Processes of Research Lesson**

There are four types of research lesson. First, a research lesson (연구수업) is conducted by a representative math teacher and all math teachers in the same school are invited to observe the lesson and give feedback after the lesson through pre- or post-conference. Second, in a public lesson (공개수업), parents are invited to watch and observe the lesson. Third, individual teachers can invite other teachers to his/her own classroom for them to observe the lesson and make suggestions (동료장학). Fourth, individual teachers can videotape their own lesson for research purpose or to reflect (자기장학). Teachers are obligated to conduct a research lesson twice a year and a public lesson twice a year. I asked teachers, “Could you explain the process of a research lesson?
What type of preparation is done before the lesson, what do observing teachers look for in the lesson, and what process happens after the research lesson?”

The preparation involved developing a lesson plan based on the selection of a unit to cover and learning objectives, and seeking tasks to motivate students. Unlike a usual lesson, the research lesson is very structured. Teacher Koh explains, “I try to follow the theoretical underpinning of how a lesson should be structured – the introduction, motivating students, learning objectives, and so forth. I try to structure the lesson in an order. Then, I prepare learning resources, things that enable students to be engaged in an activity.” Like Teacher Koh, the majority of teachers voiced that they think it crucial to prepare resources for students to become engaged in some type of hands-on activities or small group activities. Teacher Cho prepared group activities such as games, experiments, creating, and drawing, from which students are expected to discover mathematical concepts. Teachers also thought it is important to prepare multimedia equipment to show PowerPoint slides, internet websites through television or computer, and computer programs related to math. In summary, teachers develop lesson plan, prepare visual aids, multimedia equipment, and resources for small group activities, and develop formative-assessment worksheets. In addition, Teacher Yang solicited feedback from senior teachers for her preparation. Then, the teachers get approval from principal, assistant principal, and teacher in charge of research (연구부장 선생님).

During the research lesson, other teachers observe the lesson at the back of the classroom with an evaluation form that they have to fill in. The observing teachers observe the lesson according to the framework of the evaluation list: Did the teacher ask questions appropriately at the beginning, in the middle, and at the end of the lesson? Was
the learning goal introduced well? Was the lesson content delivered in a fashion that students could understand well? Was the important concept being emphasized? How did the instruction go? How is the learning environment? How much of the learning goal was met? A teacher at an independent high school also described what the teachers looked for: Were students able to apply the concepts; how is the lesson content related to CSAT and be applied to essays and in-depth interviews administered in college entrance examination? Some teachers peeked into student notebooks at the back while students took notes solving problems. Teacher Cho said that while in the past teachers looked at how a teacher explained (delivered) something to students, now teachers look at teacher-student interaction and students’ engagement in activities. They ask themselves: Are students active; how well does the teacher coordinate students to become active in classroom?

After the research lesson, teachers hold a post-conference to reflect on the lesson. The observing teachers provide feedback on things that went well, and parts that could be improved in the future. The teacher who conducted the lesson discusses what was intended through the lesson and what did not go as intended, and shares his/her own evaluation of the lesson. Teacher Hwang noted,

It is difficult to change the instruction. I think I continue the teaching model that was developed in my early years of teaching. Changes occur little by little, but it is difficult to change a whole lot. The research lesson especially takes place once in a while, so it deviates from how I would teach ordinarily, but my daily instruction is not so different from what I did in my early years of teaching.
Discussion

In this chapter, I first explored government educational and assessment policies that impact teachers’ formative assessment practices. The educational policies included (a) two-plus-one or three-plus-one policy, utilizing lab classrooms for math subject, and (b) 2009 curricular reform with story-telling approach and self-directed learning. The assessment policies included (a) standards-based assessment, and (b) long-descriptive-written type of assessment.

Then, I explored the structure and contents of professional development programs. There are qualification training, job training, and special training offered at professional development institutes. In addition, each school unit is responsible for implementing changes by engaging their teachers in various professional development opportunities such as carrying out research lessons, holding research group meetings, having a teacher deliver training, and having teachers observe others’ lessons.

The contents of the professional development programs are directly influenced by the new educational and assessment policies. From the teacher interviews, I found that the range of contents is varied. For example, there are programs related to teaching math, those pertinent to all subject areas, and those for pursuing teachers’ interests. I focused my attention on contents that are related to math, especially those that would influence teachers’ formative assessment practices. Unlike the findings of my pilot study of two Korean-American teachers in the U. S., Korean teachers agreed that there are no such programs focused solely on formative assessment; it was mentioned, yet among other larger contexts. Rather, teachers told me that they learned about formative assessment in
their pre-service education in undergraduate studies, from their own teaching seeking advice from senior teachers, or through other sources such as reading books.

I shifted my attention to identifying professional development programs that would have potential to impact teachers’ formative assessment practices from all the programs the teachers described. I could identify three that are influencing teachers’ daily instruction: (a) long-descriptive-written assessment, (b) standards-based assessment, and (c) classrooms designed for math subject. These are identical to the assessment policies currently reinforced. From this observation, two things have become clear to me: (a) the important role of professional development programs and (b) that of the teachers in unit schools working hard to implement assessment policies put forth by the government.

Because of the rise of the new type of assessment (i.e., long-descriptive-written assessment), teachers devote time for instruction to teach the necessary skills to students. Since standards-based assessment is being promoted, the whole assessment paradigm has shifted from comparison of students to a focus on an individual student’s progress/growth. These have impact on teachers’ formative assessment practices in their daily instruction.
Chapter 7

Conclusion and Implications for Future Research

I conducted an in-depth interview study of twelve Korean middle- and high-school math teachers to investigate their understanding of formative assessment. My research questions were three-fold. First, what are Korean middle- and high-school math teachers’ understandings of formative assessment? More specifically, what are the formative assessment practices that the teachers identify, and what formative assessment strategies do they use before, during and after teaching? Second, what are the policy contexts in which teachers do their work? More specifically, how do Korean math teachers feel that current education policy (social, political, and educational) impacts their formative assessment practices? Third, how do the teachers come to learn about formative assessment practices? More specifically, what role does professional development play in both learning and implementation? Furthermore, what is the role of lesson planning and other learning opportunities in teachers’ implementation of formative assessment? In this chapter, I discuss seven research findings, limitations of the study, and propose further research.

Discussion of Research Findings

Finding one: Korean teachers were able to distinguish between formative and summative assessments. The first finding is that Korean teachers were able to distinguish between formative and summative assessments. In discussing issues in defining formative and summative assessments, Bennett (2011) supports the following approach to defining the terms: (a) summative assessment can fulfill its primary purpose of documenting student records, and meet a secondary purpose of advancing learning; (b)
formative assessment can fulfill its primary purpose of supporting learning, and meet a secondary purpose of making overall informal judgments of student achievement. Although this way of defining formative and summative assessment is meaningful, it is important to first make a clear distinction between the two before showing that formative and summative assessments can somehow serve their primary and secondary purposes.

According to the Korean teachers, summative assessment is an overall evaluation of students’ academic achievement and is used to evaluate how well learning objectives have been met in a major educational period. In terms of the timing, summative assessment is administered in the final stage when a chapter is completed or when a semester is over. Several teachers have noted that summative assessment is used to keep detailed records of students’ academic progress, and that it directly impacts grades on students’ academic report cards, which play a critical role in entering high schools or colleges and universities. Examples of summative assessment are schools’ regular exams, such as mid-terms and final exams, teacher-prepared paper-based assessments, quizzes for grading purposes, and mock-tests to prepare students for high school or college entrance examinations.

In Korean teachers’ own words, formative assessment is conducted during instruction to check how well students are following the instruction. Teachers defined formative assessment with reference to learning objectives and instructional content. Formative assessment provides helpful information for both teachers and students. For example, teachers get useful information for improving their own instruction as well as for providing feedback to students about how they can improve their work. Examples of formative assessment are: (a) observations, (b) teacher questioning and solicitation of
Finding two: Korean teachers demonstrated a wide range of formative assessment practices and strategies. The formative assessment literature (Black & Wiliam, 1998, 2009; Stiggins, 2010) indicates that formative assessment involves (a) creating high-quality assessment tasks before instruction, (b) eliciting evidence of student learning, (c) interpreting elicited evidence of student learning, and (d) communicating assessment results to students, during instruction, and (e) making adjustments to subsequent instruction, after instruction. Korean teachers’ formative assessment strategies fall around the three practices of eliciting evidence of student learning, interpreting elicited evidence of student learning, and making adjustments to subsequent instruction.

First, Korean teachers elicit evidence of student learning through four strategies: (a) questioning and soliciting answers, (b) written and oral presentations, (c) use of quizzes and tests, and (d) small group activities. Questioning and soliciting answers can happen at the beginning, during, or at the end of instruction. Teacher Koh uses the questioning strategy to give opportunities for students to discover important things on their own, or to emphasize important mathematical concepts. For written and oral student presentations, teachers have student presenters come to the front and write their solution strategies on the board, while having the remaining students write their own strategies in their notebooks. The teacher walks around the class to check students’ written work in the notebook and on the board. By observing the written form and listening to the oral presentation, the teacher makes sure the students are able to explain their thinking.
verbally. The presentation of student strategies is sometimes followed by additional teacher questioning and provision of feedback, and lays the ground for discussion among students. Teachers use tests and quizzes to gauge levels of student understanding. They prepare a set of problems for students to solve at the end of the instruction. Small group activities, bingo games, and math journaling are introduced.

Second, Korean teachers interpret the elicited evidence of student learning through students’ verbal and written expression. Teachers interpret verbal expression, including (a) student responses from teacher solicitation or elicitation, (b) discussion among students, and (c) student questions addressed to their teacher. Teacher Cho acknowledged that to verbally express knowledge requires a deep thought process and a thorough review of learning material. Teachers also examine written expressions, such as solution strategies written on the board or in students’ notebooks. It is important to note that Korean teachers find information from formative assessment practice (e.g., observation of students at work during instruction) more helpful in understanding student thinking than information obtained from summative assessment (usually multiple-choice items). This viewpoint is contrary to a long-held belief among U. S. teachers that test results provide a more valid and reliable source than teachers’ firsthand observation (Erickson, 2007; Watt, 2005).

Third, Korean teachers make adjustments to subsequent instruction by using assessment information. Assessment information can be interpreted in two ways: (a) assessment information from observation of students at work during daily instruction, and (b) assessment information from paper-based assessments. Assessment information from observation of students at work during daily instruction was used to supplement the
previous lesson and guide the next lesson. Teachers (Teacher Ryu, Teacher Hwang, Teacher Ahn, and Teacher Jeon) re-taught or taught differently by adjusting the level of difficulty, and they provided lots of examples or made use of visuals to promote student understanding. Teacher Kang modified her instructional methods and reconstructed the learning materials to promote student understanding. Assessment information from paper-based assessments was used so that teachers can make decisions concerning which students would have to re-take the test (Teacher Yoon), to make decisions on changing student members in classrooms (Teacher Choi), and to have students keep notes of problems that they answered incorrectly (Teacher Yang).

**Finding three: Pedagogical content knowledge played an important role when Korean teachers examined students’ work on two-digit multiplication problem.** The Korean teachers have strong pedagogical content knowledge about the two-digit multiplication task. They explained in detail about the concept of the place value system, how a number is composed, the meaning of multiplication, multiplication by 10 and powers of ten, and the distributive law. These concepts are similar to what Ma (1999) says about the knowledge package for multiplication by multi-digit numbers. Furthermore, teachers used manipulatives, such as ones cube, tens block, and hundreds flat, for different purposes: (a) to represent an area model, and (b) to represent the bundles concept. One teacher devised a completely different instructional tool, the stones-in-boxes model, a similar approach to the bundles concept.

**Findings four: Teachers’ difficulties or differing opinions about examining students’ work in part-whole comparisons have implications for how teachers interpret students’ work, which is an important aspect of formative assessment.**
Four teachers (Teacher Seo, Teacher Shim, Teacher Yang, and Teacher Yoon) supported Derek’s strategy, that “the shaded area can be expressed as one-half in both pictures” and that “they are the same amount because half the picture is shade.” The four teachers interpreted the problem and saw that the whole circle can be abstracted into a numeric number 1, and that the whole rectangle can also be abstracted into a numeric number 1. Since they abstracted a numeric value, 1, out of the two different shapes, the halves of each of them are the same.

Seven teachers (Teacher Ryu, Teacher Jeon, Teacher Kang, Teacher Koh, Teacher Cho, Teacher Ahn, and Teacher Hwang) supported Adam’s strategy, that “the shaded area can be expressed as one-half in both pictures” and that “it is the same fraction but not the same amount.” Among them, three teachers (Teacher Ahn, Teacher Jeon, and Teacher Koh) supported his strategy by claiming that when we measure a half of an object, it matters which object we begin with. Teachers used terms such as “standard,” “benchmark,” or “the whole” to mean the object we start with. The discussion below highlights important points the teachers made:

Teacher Ahn: If the given amount is the same at the beginning for each object, then one-half of them would be the same. However, when we begin with different objects such as a rectangle and a circle, then a half of a rectangle and a half of a circle can be different.

Teacher Jeon: Similar to the concept that a half of an apple and a half of a pear are different, I think I can say that the amount would be different.
Teacher Koh: When measuring the amount, the circle itself, or the rectangle itself, or the object itself as a whole, was different originally, so the amount of the half of them would be different.

Among the seven teachers who favored Adam’s strategy, four teachers (Teacher Cho, Teacher Kang, Teacher Hwang, and Teacher Ryu) supported his strategy on the grounds that the “area” of the shaded part is different. These four teachers interpreted the amount as an “area” of the shaded parts of the figures. Teacher Cho’s words are representative of the other teachers’ responses. She used a term, “absolute amount,” to refer to the actual area.

Teacher Cho: Adam does know that the ratio is ½, if it is 2 out of 4 or if it is 4 out of 8. He says, “It is the same fraction, but not the same amount.” This means that the absolute amounts are clearly different, but the ratio itself is the same. So he means that the fraction is the same, in other words, it has the same ratio, but the absolute amount is different. They can’t be the same amount – it means that the value itself is different.

Derek says, “2/4 is colored, and 4/8 is colored, and they are the same.” When he says “they are the same,” I think he is referring to the ratio itself. He only considered the ratio, but didn’t take into account the absolute amount – in other words, the absolute amount of the specific area. Derek does not take into account the area or absolute amount. Because when he says “they are the same,” it means the ratio itself, the ratio of 2 to 4 and the ratio of 4 to 8. If he were to be precise, he should have written or mentioned, “the ratio is the same” or “they have the same value as a fraction.”
There is one area where teachers had different views. For example, while Teacher Kang supported Adam’s idea of overlapping two figures to compare the amount of shaded area, Teacher Cho and Teacher Ryu raised a concern in using pictorial representation to reach a conclusion because the size of the shapes were not provided. Teacher Ryu also acknowledged possible different interpretations of the original problem given to students, which could have influenced teachers’ difficulties or differing opinions about examining students’ work.

**Finding five: The Korean teachers’ thoughts about convergent and divergent approaches to teaching and learning were elicited.** In the first scenario, the teacher presents the law of exponents at the beginning of the lesson, and has students solve similar problems by substituting numbers into the formula. For example, Teacher Jeon pointed out from the scenario that “because when the teacher asked, ‘what if n=6, a=2, b=3? (how can it be applied?)’ the student was able to apply the numbers into the formula, but not knowing what it meant. I saw that the student answered, ‘I substituted (the numbers into the symbols).’” The first scenario represents a convergent approach to teaching and learning. In this approach, teachers can teach a lot of content within a small amount of time. However, this approach limits student thinking and takes away time for students to think mathematically about the process of how the formula was derived.

In the second scenario, the teacher gives concrete examples, enables students to expand upon those concrete examples to find patterns and to turn the numeric expressions into a generalized symbolic formula. For example, Teacher Ahn pointed to a specific line in the scenario: “In the very last line in the second scenario, the teacher asks, ‘Is there a way to use symbols to represent what Theresa just said?’ – It shows that the class is
trying to make the concrete into symbolic representation.” The second scenario represents a divergent approach of teaching and learning. In this approach, students are encouraged to construct new knowledge by using their prior knowledge. They might approach math with joy because they are actively seeking ways to construct knowledge in their own way. In a way, students are becoming mathematicians themselves. Korean teachers acknowledged that time constraints, having to cover certain amount of contents in a given time, and a large number of students per classroom, hinder them from practicing this approach.

There were teachers who were consistent in their beliefs and practices. For example, six teachers (Teacher Hwang, Teacher Ahn, Teacher Koh, Teacher Kang, Teacher Ryu, and Teacher Yang) thought that the second approach was better, and that the second approach best characterized how they teach. Three teachers (Teacher Shim, Teacher Choi, and Teacher Yoon) thought that the first approach was better, and that the first approach best characterized how they teach. There were teachers who showed a mismatch between their beliefs and practices. For example, Teacher Cho thought the second approach was better for children, and yet she uses both approaches case-by-case. She takes the first approach 60% of time when teaching algebra, when time is lacking, and when instructional tools are lacking. She takes the second approach 40% of the time when teaching shapes or graphs, or teaching chapters that can be handily taught using multimedia equipment. Teacher Jeon thought that the second approach is the direction where math education should be heading, yet she felt that taking the second approach is a bit difficult in reality, because of time constraints, large number of students per class, and the difference of students’ achievement levels. As such, she takes the middle approach.
Teacher Seo thought that both approaches have their own good and bad aspects. She takes the first approach usually, but probes student thinking (the second approach) when starting a new chapter.

**Finding six: There was a possible difference between middle and high school teachers’ assessment practices.** Duncan and Noonan (2007) found that teachers embrace some form of assessment reform while maintaining traditional practice. More specifically, they found, from survey questionnaires of 513 Canadian high school teachers, that high school math teachers demonstrated lower use of reformed-approach assessments, while they preferred using more traditional assessment forms. In-depth interview data from Korean teachers indicates that two to three middle school teachers out of seven thought that the first approach (convergent) characterized their teaching, while three high school teachers out of five thought so. In other words, 22-43% (less than half) middle school teachers characterized their teaching as traditional, while 60% (more than half) high school teachers characterized their teaching as traditional. Although it is difficult to make generalizations about the differences of middle and high school teachers’ assessment practices from the small number of teachers (n=12) involved in my study, I find it important to document this finding.

**Finding seven: Government education policies and teachers’ professional development programs were tightly interwoven.** – They reinforced each other so that teachers could adopt the new education policies into their practice. Two assessment policies were identified that have impact on teachers’ formative assessment practices. First, standards-based assessment is an assessment of student achievement against their position to an absolute standard, rather than comparison of student ranks
against their peers. It adopts a criterion-referencing method to determine students’ grades with regard to absolute standards and the levels of performances for each standard, rather than using a norm-referencing method of ranking students within a bell-curve. Second, in accordance with the standards-based assessment, long-descriptive-written assessment was introduced, whose prevalence in schools’ regular exams is increasing year by year. It requires students to write down the process that led to the solution they are proposing. It requires teachers to develop scoring guidelines, assign how much credit to give for each step, and anticipate possible student answers and similar answers. Teachers in math departments hold grading committee meetings multiple times for moderation processes to reach an agreement. They also go through appeal processes with students when students raise complaints about their grades.

The professional development programs regurgitate the government assessment policies. For example, to pass down long-descriptive-written assessment into classroom practice, teachers are introduced to how to develop test items, how to create scoring guidelines, and how to assign partial credits. Then, they are asked to grade student work samples. Even though teachers are exposed to the new assessment policies through professional development programs, teachers themselves have to reflect and act upon how they might apply it to their own teaching practices. Teacher Shim voiced the importance of the role of unit schools in implementing new assessment policies: “The most important thing is how the unit schools actively seek ways to implement it. The Ministry of Education or the Office of Education at the Province- or city-levels, they try to promote and spread the new assessment policy, but the remaining parts have to be acted upon by teachers at the unit schools. Even though they pass down good things from
above, if the unit schools do not respond accordingly, it does not happen. So, the teaching practitioners have to be engaged in research and apply it actively.”

Limitations of the Study

There are several limitations to this study. First, the sample size is small; twelve teachers. Initially, I proposed to conduct interviews with ten teachers, five middle school and five high school math teachers. However, I recruited two more middle school teachers towards the end of my fieldwork. I recruited more teachers towards end of my fieldwork because I wanted to make sure the data that I have gathered thus far would be representative and to see if there was any more data that I needed to solicit. I recruited two more middle school teachers because literature (Duncan & Noonan, 2007) indicates that middle school teachers are more likely to practice formative assessment than their high school counterparts.

Second, the research was conducted in a capital city of a Southwestern Province in South Korea, so one has to be cautious when relating the research findings to other settings. As was pointed out by teacher participants, the province under study had its own education policy for high school entrance. Whereas middle schools in other provinces abolished the high school entrance examination in the past, the province under study still administered the high school entrance examination at the end of students’ third year of middle school. This indicated that middle school teachers in the province are responsible for teaching their students to become familiar with the new type of assessment (i.e., long-descriptive-written assessment) promoted throughout the country, while also having to teach to the types of problem posed in high school entrance examinations (mostly multiple-choice items and short-answer problems) still administered in the province. One
must be careful to understand the unique situation in which the teachers in this study are located.

Third, this interview study relied on teachers’ self-reports of their formative assessment practices. For example, during an interview, I asked teachers which approach (convergent or divergent) is better than the other and which approach best characterizes how they teach. Although teachers’ responses to the above questions had to be verified through formal classroom observations, I relied on teachers’ best judgments about their instruction. As it turned out, the interviews produced teachers’ own words, which were more helpful because teachers addressed both the merits and shortcomings of each convergent and divergent approach to teaching and learning. Teachers could discuss in detail why they taught in a certain way, and what hindered them from adopting the other approach. Moreover, I administered the fifth interview to examine teachers’ formative assessment knowledge by having them interpret students’ written work and classroom scenarios, which is a necessary component of formative assessment. In addition, I conducted three informal classroom observations to triangulate the data gathered from the interviews.

Implications for Future Research

This study investigated (a) Korean teachers’ understandings of formative assessment, and their formative assessment knowledge through examining students’ written work, and; (b) the larger educational/assessment policy climate, in which teachers are working to implement formative assessment, and teachers’ opportunities for learning about formative assessment (professional development).
For future research, I would like to pursue teachers’ formative assessment practices in the climate of assessment reform (long-descriptive-written assessment and standards-based assessment). From this study, I learned that Korean students are required to produce long-written explanation on paper-based assessments. With the rise of this new assessment policy, teachers spend time during regular class periods preparing students to produce sound mathematical sentences. Teachers are introduced to this new type of assessment in professional development programs provided by the Office of Education. They are trained in how to develop sound test items for the long-descriptive assessment, and how to grade students’ responses to the test items. Within the unit schools, teachers hold multiple grading committee meetings for fair evaluation of student answer sheets.

In addition, I would also like to be involved in a professional development program that fosters formative assessment practices in the U.S. – a one-year program that meets once a week (12x4=48 times). The professional development program involves math teachers to promote more diverse and robust formative assessment practices and strategies, and also promote teachers’ understanding of discourse-based formative assessment practices (DAP). In this study, it was difficult to make generalizations about the socio-economic status (SES) of the student populations in schools and its relationship to high or low use of formative assessment practices and strategies, because of small sample size. In the future, I would like to investigate whether there are differences in teachers’ formative assessment practices among schools with different socio-economic status (SES), and study the implications.
References


Crockett, M. D. (2012, April). Formative assessment and mathematics teaching and learning. *MSTE lunch lecture series*. Lecture conducted from the University of Illinois at Urbana-Champaign, Urbana-Champaign, IL.


Appendix A

Final copies of recruiting materials

Dear Name,

My name is Sun Hee Lee, a doctoral candidate in the Department of Curriculum and Instruction at the University of Illinois at Urbana-Champaign. I am looking for volunteers, for my dissertation research study. I would like to learn about middle- and high-school math teachers’ understanding of formative assessment and how they use it in their teaching. This will be an interview study, consisting of five thirty-minute interviews that will be scheduled according to your convenience.

If you have taught secondary mathematics for at least one year and are willing to participate in this study, please send me an e-mail at lee771@illinois.edu. Thank you very much for your interest in my study.

Sincerely,

Sun Hee Lee
안녕하세요? 저의 이름은 이선희입니다. 저는 일리노이 대학 (University of Illinois at Urbana-Champaign)에서 박사과정으로 수학교육학을 전공하고 있습니다. 저는 저의 박사논문의 연구에 참여를 해주실 분을 찾고 있습니다. 저는 한국의 중고등학교 선생님의 형성평가에 대한 이해와 선생님들이 수업에서 가르치는데 형성평가를 어떻게 활용하고 게시하는지에 대하여 연구하고 있습니다. 제 박사논문으로 인터뷰 연구를 하려고 합니다. 약 삼십분 정도가 소요되는 인터뷰를 다섯 번에 걸쳐서 실행하려고 합니다. 시간과 장소는 선생님이 편하신 때로 스케줄을 잡으려고 합니다.

만약 적어도 영어 이상 중등과정 수학을 가르치신 경험이 있으시고, 저의 연구에 참여하고 싶으시다면 저에게 이메일을 주시기 바랍니다. 제 이메일주소는: lee771@illinois.edu 입니다. 저의 연구에 관심을 주셔서 대단히 감사드립니다.
이선희 드림
Appendix B

Interview Protocol

Introduction

1. Thank you very much for participating in my study. This is a doctoral dissertation study to explore Korean middle- and high-school math teachers’ understanding of formative assessment. I will ask some questions about your thoughts and opinions. What you share in this interview will be kept confidential, so please tell me what you really think and feel. This will be very helpful in exploring how to improve teaching and learning in secondary-school math classrooms.

2. Each interview will take about thirty minutes.

3. I will tape-record the interview to make sure that I have an accurate record of your views, and also take a few notes for the same purpose. Do you mind if I tape-record and transcribe this interview and take some notes from your responses during this interview?

Demographic information of the teacher (Educational background and teaching experiences)

Educational background:

4. What was your major in undergraduate studies?

5. What was your focus in graduate studies?

Past teaching experiences:

6. How long have you been teaching in middle/high schools?

7. What grade level(s) have you taught?

Current teaching responsibilities:
8. At which school do you work currently? What grade are you teaching? If you are teaching at a high school, which track are you teaching? (There are two tracks in Korean high schools: a track focusing on Korean and foreign language, and a track focusing on math and science.)

9. Demographic information about your students: How many classes are you teaching? How many students are in your classrooms? How many are male and how many female? Where is your school located -- urban, suburban, or inner-city? What is the socio-economic status of your students?

**First and second interviews. General questions about formative assessment**

10. Describe a usual class period. (For example, how much time is spent on checking the class roster, on getting attention, on the whole-class lecture, on small-group activities, and on whole-class mini lecture?)

**Your own definition of formative assessment**

11. When you hear the word assessment, what comes to mind?


13. How do you check whether your students have learned what you have taught? (Wiliam, 2007)

14. Define formative assessment in your own words. What are examples of formative assessment?

15. Define summative assessment in your own words. What are examples of summative assessment?

16. How do you use assessment information in designing/planning your lessons?
17. Please describe how you practice formative assessment in your daily instruction (Black & Wiliam, 2009; Wiliam, 2010).

18. What are examples of formative assessment strategies that you use regularly in your daily instruction? Describe the process of applying these techniques (Thompson & Wiliam, 2008).

19. As a teacher, what information from your formative assessment practices help you understand student thinking?

20. What are some challenges to administering formative assessment practices/strategies in your classrooms? (Erickson, 2007; Heritage, Kim, Vendlinski, and Herman, 2009; Saxe et al., 1999; Watt, 2005)

**Impact of educational policy on formative assessment practices**

21. Would you briefly explain the student grade-management system in your school?

22. Tell me about governmental policies. Do they affect your teaching? How?

23. Tell me about the College Scholastic Ability Test (CSAT; Sooneung). Does it affect your teaching? How? Why?

24. What do you think about hagwon? How does it affect what you do in your classroom?

25. How are you responding to government assessment policies? Do you feel prepared to respond to them? Why or why not? (Torrance & Pryor, 1998, p. 23)

**Third and fourth interviews. Clarifying and building upon teachers’ responses from the previous interviews**

The third and fourth semi-structured interviews will expand on the teachers' answers from the previous interviews, and will include supplemental questions that arise. The
researcher will follow up on any issues that may have transpired during the previous interviews. Three possible topics to be discussed are teachers’ experiences of professional development programs or workshops, their use of lesson planning, and teachers’ teaching philosophy.

Learning opportunities about formative assessment: Professional development programs, workshops, lesson planning

26. Where do you learn about formative assessment practices?

27. Do you attend workshops or professional development programs?

28. How often do you prepare your lesson planning material?

Structures and contents of the workshop or professional-development experiences

29. [Content] What is the workshop/PD about? What is the curriculum of the workshop/PD?

30. [Structure] How is it organized?

31. Is it somehow related to formative assessment? How do you see that formative assessment is fostered during the workshop/PD? Is a formative assessment component included in the workshop/PD?

32. Could you describe one day at a workshop/PD?

Impact on teachers’ instruction

33. What do you learn? What are the most important things that you learn from attending the workshop/PD?

34. Have you had a chance to give a lesson after the workshop/PD? How did it come out?

35. How do these experiences influence your instruction?
36. How does lesson planning influence your teaching with regard to your formative assessment practices?

Teaching philosophy

37. If you were to mentor a student teacher who is on his/her practicum, what suggestions would you provide to him/her regarding student learning and teaching?

38. What is your approach to teaching mathematics? What are your beliefs about effective math instruction?

39. If you find a student who is struggling in a math class, how would you get him/her to move from where they are to where they aim to be?

Fifth interview. Opportunity to explore teachers’ discourse-based formative assessment practices

First task: Two-digit multiplication problem

40. The exhibit questions below are derived from Crockett, 2012, and are modified.

Eliciting and collecting evidence of student learning:

Sixth grade teachers have noticed that several of their students solved the following two-digit multiplication problem in this way:

\[
\begin{align*}
12 \\
\times 34 \\
\hline
48 \\
36 \\
\hline
84
\end{align*}
\]

Examining and interpreting student misconceptions:

a) What is the correct answer?

b) What type of problem is this?
c) What are the strengths and weaknesses of the student’s work?

d) What are the mathematical concepts and ideas at play in this problem?

_Use evidence of student learning to inform instruction:_

a) What instructional strategies would you employ so that the student can solve the problem with understanding?

b) If you were to use manipulatives, which would you use, how would you use them and why?

c) What questions would you ask to ensure mathematical understanding prior to, during, and after teaching?

d) What feedback would you provide to this student and why?
**Second task: Part-and-whole relationship of fractions**

The following task is from Lamon (1999).

[Problem]

Name the part that is shaded in each picture. Do these fractions name the same amount? How do you know? (Lamon, 1999, p. 59)

[Student answers]

Mike: In the circle 2/2 is shaded. In the box 4/4 is shaded. They can’t be the same amount because one is a box and one is a circle.

Adam: ½ is shaded in both pictures. It is the same fraction but not the same amount. You can tell like this. (Picture included.)

Derek: 2/4 is colored in the circle and 4/8 is colored in the rectangle. They are the same because half the picture is shade. (Lamon, 1999, pp. 59-60)

[Question asked for teacher interview]

Analyze the children’s responses. Are they correct? Rank the strategies according to their sophistication, giving reasons to support your ranking. (Lamon, 1999, p. 75)
Part-Whole Comparisons

Children's Strategies

Name the part that is shaded in each picture.
Do these fractions name the same amount? How do you know?

Mike
In the circle \( \frac{3}{4} \) is shaded. In the box \( \frac{1}{4} \) is shaded. They can't be the same amount because one is a box and one is a circle.

Adam
\( \frac{1}{2} \) is shaded in both pictures. It is the same fraction but not the same amount. You can tell like this 🥤

Derek
\( \frac{3}{4} \) is colored in the circle and \( \frac{4}{8} \) is colored in the rectangle. They are the same because half the picture is shaded.

**Third task: A law of exponents**

The following scenarios have been adapted from Lampert (1990) to fit the purposes of the interview.

In the classroom scenarios below, the teacher and the students are working on exponents. Please read each scenario. Think about the similarities and differences in each.

**Classroom Scenario 1.**

Teacher: (She writes on the board: \(7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7\)). Arthur, how can I express this in exponent form?

Arthur: 7 to the 8\(^{th}\) power.

Teacher: Good job, Arthur. The teacher writes on the board: \(7^8 = 7^4 \times 7^4\). Ok, class. Look at this equation. What do you notice?

Gar: You broke 8 in half to get 2 fours.

Teacher: Excellent, Gar. \(4 + 4 = 8\). So we can take the exponent of a base and break it up into its addends. We get an important law of exponents \((n^a)(n^b) = n^{a+b}\).

Teacher: Theresa, what if \(n = 6\), \(a = 2\) and \(b = 3\)? Come write it on the board.

Theresa: She writes: \((6^2)(6^3) = 6^{2+3}\).

Teacher: Can you simplify that?

Theresa: I substituted like you said …

Abdul: I know how to do it. It’s 6 to the 2nd power times 6 to the 3rd power equals 6 to the 5\(^{th}\) power.

Teacher: Very good, Abdul. I’m going to write some more on the board for everyone to do.
The teacher goes to the board and begins to write the first of several problems: \((5^3)(5^6) = 5^9\)

Classroom Scenario 2.

Teacher: The teacher writes on the board: \(7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7\). What power is this?

Arthur: 8th.

Teacher: That's \(7^4\) squared. She writes on the board: \(7^8 = 7^4 \times 7^4\)

Teacher: What's \(7^{16}\), Arthur?

Arthur: It's going to be \(7^8 \times 7^8\).

Julio: I think \(7^{16} \times 7^{16}\) is going to be \(7^{32}\). It just doubles.

Soo Wo: Since \(7^3\) is 343, I think \(7^6\) would be \(7^3 \times 7^3\), which would be 343 x 343.

Teacher: What do you think about \(7^3 \times 7^2\)?

Molly: That's going to be the same as \(7^5\).

Teacher: How do you know?

Molly: I already know that 7 cubed is 343 and 7 squared is 49. So \(7^5\) is going to be 343 x 49.

Theresa: When you multiply the same bases, you can add the exponents. So \(7^2 \times 7^3 = 7^5\).

Teacher: Is there a way to use symbols to represent what Theresa just said?

The students start working on a symbolic representation.

Questions:

1. What are your general impressions of the scenarios?
2. What is the teacher trying to get the students to learn in the scenarios?

3. What similarities and/or differences do you see between the two scenarios?

4. What do you think about the teacher’s approach in the first scenario?

5. What do you think about the teacher’s approach in the second scenario?

6. Do you think one approach is better than the other? Why?

7. Is there anything you would do differently? Why?

8. Which approach best characterizes how you teach? Please elaborate. (Have the teacher point to examples in the scenarios and in their own teaching that the think is similar or dissimilar.)

9. How frequently do you teach this way? When does your teaching depart from this? Why?
도입
1. 저의 연구에 참여해주셔서 대단히 감사합니다. 저의 이름은 이선희입니다. 이것은 한국의 중고등학교 수학 선생님들의 형성평가에 대한 이해를 연구하기 위한 박사논문 연구입니다. 저는 선생님들의 생각과 견해를 들어보는 질문을 할 것입니다. 선생님께서 이 인터뷰에서 공유하는 것은 비밀이 지켜질 것이므로 선생님께서 어떻게 생각하고 느끼는지에 대하여 얘기해주시기 바랍니다. 이것은 중등 수학 수업에서 선생님의 가르침과 학생의 배움이 향상되는데 매우 유용할 것입니다.
2. 각각의 인터뷰는 대략 삼십분 정도가 소요될 것입니다.
3. 저는 선생님의 생각과 견해에 대하여 정확한 기록을 갖기 위해서 인터뷰를 음성녹음을 하려고 합니다. 그리고 동일한 이유로 인터뷰 중에 노트를 쓰려고 합니다. 제가 인터뷰 도중에 음성녹음을 하여 나중에 전사를 하고, 인터뷰 중 선생님의 대답을 노트에 적어도 괜찮을까요?

선생님의 인구통계학적 자료 (선생님의 학력사항과 교사경력)

선생님의 학력사항:
4. 학부에서 무엇을 전공하셨습니까?
5. 대학원에서 무엇을 전공하셨습니까?

이전의 교사경력:
6. 중학교/고등학교에서 몇년동안 가르치셨습니까? 년도별로 근무학교를 알려주시기 바랍니다.
7. 몇학년을 가르치셨습니까? 년도별로 구체적으로 알려주시기 바랍니다.

현재의 가르치는 책임:
8. 현재 근무하고 계시는 학교이름이 무엇입니까? 몇학년을 가르치고 계십니까? 고등학교인 경우 인문계열, 자연계열 중 어떤 과정을 가르치고 계십니까?
9. 가르치고 계시는 학급은 몇 학급이며, 각 학급당 학생 수는 몇 명입니까? 한 학급당 남학생/여학생 수는 몇 명 입니까? 선생님이 계시는 학교는 어디에 위치해 있습니까 (도시, 시내 외곽, 또는 도시 중심부)? 학생들의 사회경제적 위치는 어떠하십니까?
첫번째와 두번째 인터뷰: 형성평가에 관하여 일반적인 질문

10. 일상적인 수업시간을 묘사해주세요. (예를 들어, 출석체크 하는데, 학생들의 주의를 집중시키는데, 대그룹 강의하는데, 소그룹 협동학습을 하는데 각각 얼마나의 시간이 소요되는지?)

형성평가에 대한 선생님만의 정의:
11. “평가”라는 단어를 들으면 어떤 생각이 떠오르시니까?
12. 학생들에 대한 수학적 소질을 어떻게 평가하십니까?
13. 선생님께서 가르친 내용을 학생들이 터득했는지에 대해서 어떻게 확인하십니까?
14. 형성평가를 선생님의 언어로 정의하신다면 어떻게 하셨습니까?
15. 총괄평가를 선생님의 언어로 정의하신다면 어떻게 하셨습니까?
16. 수업도중에 수시로 학생들의 활동을 평가하게 되는데요, 그렇게 하여 얻은 학생평가 정보(assessment information)를 다음 수업을 설계하실 때 어떻게 사용하십니까?
17. 선생님의 일상적인 수업에서 정기적으로 쓰는 형성평가 방법(pactices)의 예들이 있다면 어떻게 시행하시는지 묘사해주세요. (포괄적)
18. 수업도중 선생님이 정기적으로 쓰는 형성평가 테크닉(strategies)이 있다면 무엇이니까? 어떻게 그러한 테크닉을 시행하는지 묘사해주세요. (구체적)
19. 교사로서서, 선생님이 수업을 하실 때 어떤 면이(정보가) 학생들의 수학적인 사고를 이해하는데 도움을 주나요?
20. 수업도중 형성평가를 시행하는데 만약에 장애물이 있다면 어떤것이 있습니까?

교육정책이 형성평가를 실행하는데 미치는 영향:
21. 선생님이 근무하시는 학교의 학생 성적 관리 시스템을 간략하게 설명해주세요.
22. 정부의 교육정책에 대하여 말씀해주세요. 그것은 선생님의 가르침에 영향을 줬니까? 어떻게 그렸습니까?
23. 대학수학능력시험에 관련된 정책에 대하여 말씀해주세요. (중학교인 경우에는 고등학교 입시제도와 정책에 대하여 말씀해주세요.) 그것은 선생님의 가르침에 영향을 줬니까? 어떻게 그렸습니까? 왜 그렸습니까?
24. 학원 (사교육)에 대하여 어떻게 생각하십니까? 선생님이 수업시간에 하는 것에 어떻게 영향을 줄니까?

세번째와 네번째 인터뷰: 이전 인터뷰에서 선생님이 해주신 답변을 분명히 하고 확장시킵니다.
세번째와 네번째 인터뷰는 이전 인터뷰에서의 선생님의 답변을 조금 더 확장하고자 합니다. 이전 인터뷰에서 얘기했던 이슈에 관하여 부수적인 질문을 하려고 합니다. 세번째와 네번째 인터뷰에서 다른 이론 가능한 주제들은 선생님의 교사연수과정에 대한 경험, 수업지도안에 대한 경험, 그리고 선생님의 교육철학 입니다.

형성평가에 관한 배움의 기회: 교사연수과정, 워크샵, 수업지도안 -
26. 형성평가에 대하여 어디서 배우나요?
27. 워크샵이나 교사연수과정 프로그램에 참여하신 적이 있나요?
28. 수업지도안은 얼마나 자주 만드십니까? 연구수업이나 공개수업은 얼마나 자주하시나요?

워크샵 혹은 교사연수 프로그램의 구조와 내용:
29. [내용] 워크샵/교사연수는 무엇에 관한 것입니까? 워크샵/교사연수의 교육과정 및 내용은 무엇입니까?
30. [구조] 워크샵/교사연수 프로그램이 어떻게 구성/조직/편성되어 있나요?
31. 형성평가와 관련된 부분이 있나요? (혹은 수학교수법이나 평가 전반을 다루는 프로그램이 있나요?) 워크샵이나 교사연수에서 형성평가가 어떻게 촉진되어지고 있다고 생각하십니까? 워크샵이나 교사연수에 형성평가에 관한 부분이 포함되어 있나요?
32. 워크샵/교사연수 프로그램에서의 하루를 묘사해주실 수 있으십니까? 혹은, 연구수업 발표의 과정에 대하여 설명해주십시오. 수업전에는 어떤 과정을 거치고, 수업도중에 참관하시는 선생님들은 어떤 면을 중점적으로 보시고, 수업후에는 어떤 과정이 이루어지나요?

선생님의 수업에 미치는 영향:
33. 워크샵 혹은 교사연수 프로그램을 참여함으로써 무엇을 배우나요?
그리고, 배우는 것 중 어떤 면들이 중요하다고 생각합니까?
34. 워크샵, 교사연수, 혹은 연구수업 발표 후에 그를 반영하여 수업을 해보신 적이 있습니까? 수업이 어떻게 진행되었나요? 구체적인 예를 들어 그 수업을 묘사해주세요.
35. 이러한 경험(워크샵 혹은 교사연수 프로그램)이 선생님의 가르침(교수법)에 어떤 영향을 미쳤다고 생각하십니까?
36. 수업지도안을 짰는 것, 혹은 연구수업 발표의 경험이 수업을 향상시키는데 어떻게 영향을 미쳤습니까?

선생님의 교육철학:
37. 교육실습을 나온 교생선생님을 지도해야 한다면 가르침과 배움(교수학습)에 대하여 어떤 조언을 주시겠어요?
38. 수학을 가르치는 것에 대하여 선생님은 어떻게 접근하나요? 효과적인 수학 교육방법은 무엇이라고 생각하시나요? 그리고 거기에 대하여 어떠한 신념을 가지고 계신가요?
39. 어떤 학생이 수학수업을 잘 따라가지 못한다면, 어떻게 지금 그 학생의 수준에서 그 학생이 원하는 단계로 끌어올리시니까?
다섯번째 인터뷰: 선생님들의 담화를 토대로 한 형성평가 둘러보기

첫번째 활동: 두자리수 곱셈문제

40. 아래 질문들은 Crockett (2012) 워크샵 자료에서 발췌하였습니다.

학생의 배움의 근거를 이끌어내고 수집함:
육학년을 가르치는 선생님이 다음의 두자리수 곱셈문제를 몇명의 학생들이 아래와 같이 풀었습니다.

\[
\begin{align*}
12 & \times 34 \\
\hline
48 & \\
36 & \\
\hline
84 & 
\end{align*}
\]

학생들이 잘못 이해하는 부분을 검토하고 해석함:
a) 무엇이 올바른 답입니까?
b) 이것은 어떤 타입의 문제입니까?
c) 학생 답안의 강점과 약점은 무엇입니까?
d) 이 문제에 제시되어 있는 수학적인 개념과 아이디어는 무엇입니까?

학생의 배움의 근거를 숙지하여 가르침에 활용함:
a) 학생이 이 문제를 이해하며 풀 수 있도록 어떤 교수방법을 사용할 것입니까?
b) 만약 학습용 도구(manipulative)를 사용한다면 어떤 도구를 이용할 것이며, 어떻게 이용하고, 왜 그 도구를 이용할 것입니까?
c) 학생들의 수학적인 이해를 돕기 위해 수업 전에, 수업 도중에, 그리고 수업 후에 어떤 질문을 제기할 것입니까?
d) 위의 학생들에게 어떠한 피드백을 주시겠습니까?
두번째 활동: 분수의 부분과 총합에 관한 문제

다음은 Lamon (1999)에서 발췌하였습니다.

[문제] 각 그림 (그림참조)에서 빗금치진 부분을 이름지어보세요 (표현해보세요). 이 분수들은 똑같은 양을 청하는건가요? 어떻게 아는가요?

[학생들의 답안]
Mike: 원에서는 2/2 가 빗금쳐져 있습니다. 상자에는 4/4 가 빗금쳐져 있습니다. 그 둘은 같은 양이 될 수 없습니다. 왜냐하면 하나는 상자이고, 하나는 원이기 때문입니다.
Adam: ⅓ 이 두 그림에서 빗금쳐져 있습니다. 그것은 같은 분수이지만, 같은 양이 될 수는 없습니다. 이렇게 말할수 있습니다. (그림참조)
Derek: 원에서는 2/4 가 색칠되어있고, 직사각형에서는 4/8 가 색칠되어 있습니다. 그 둘은 같습니다. 왜냐하면 그림의 반절이 빗금쳐져 있기 때문입니다.

Q. 학생들의 답변을 분석해보세요. 그것은 맞는 답입니까? 학생들이 사용한 방법들을 그들의 정교함과 세밀함의 정도에 따라서 순위를 매겨주세요. 그리고 왜 그런 순위를 매겼는지 이유를 말해주세요.
세번째 활동: 지수법칙에 관한 문제

다음의 두 발췌문은 이 인터뷰의 목적에 맞게 Lampert(1990)에서 수정하였습니다.

아래 수업의 발췌문에서는 선생님과 학생들이 지수에 관하여 배우고 있습니다. 두 발췌문을 읽어보시면서, 유사점이나 차이점을 생각해보시기 바랍니다.

첫번째 수업 발췌문

선생님: (선생님이 칠판에 \(7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7\)이라고 적습니다.)
Arthur: 이것은 지수행태로 표현한다면 어떻게 할까요?
Arthur: 7의 8승이에요.
선생님: 잘했어요, Arthur. (선생님이 칠판에 \(7^8 = 7^4 \times 7^4\)와 같이 적습니다.) 자, 여러분 이 방정식을 보고서 뭐 알 수 있을까요?
Gar: 8을 반으로 나눠서 두개의 4를 만들었어요.
선생님: 아주 잘했어요, Gar. \(4 + 4 = 8\)이죠. 우리는 밑의 지수를 취하여 조금수 있습니다. 더하면 그 지수가 되도록. 그리하여 우리는 \((n^a)(n^b) = n^{a+b}\)와 같은 중요한 지수법칙을 얻게 됩니다.
선생님: Theresa, 만약 \(n = 6, a = 2, \) 그리고 \(b = 3\)라면 어떻게 될까요?
치판에 나와서 써보세요.
Theresa: \((\text{치판에}\(6^2\))\((6^3) = 6^{2+3}\)와 같이 적습니다.)
선생님: 그것을 쉽게 표현해볼수 있나요?
Theresa: 저는 선생님이 말한대로 그렇게 대입했습니다.
Abdul: 저는 어떻게 하는 줄 알아요. 6의 2승 곱하기 6의 3승은 6의 5승과 같아요.
선생님: 아주 잘했어요, Abdul. 모두가 해볼수 있도록 조금더 칠판에 적어보도록 하겠어요.

선생님은 칠판으로 가서 몇가지 문제를 쓰기 시작합니다: \((5^3)(5^6) = 5^9\)

두번째 수업 발췌문

선생님: (선생님이 칠판에 \(7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7\)이라고 적습니다.) 이것은 몇승인지요?
Arthur: 8승이에요.
선생님: 그것은 \(7^4\)의 제곱이지요. (선생님은 칠판에 \(7^8 = 7^4 \times 7^4\)와 같이 적습니다.)
선생님: Arthur, \(7^{16}\)은 뭐지요?
Arthur: 그것은 \(7^8 \times 7^8\)입니다.
Julio: 제가 생각해봤을 때 $7^{16} \times 7^{16}$은 $7^{32}$이 될 것이라고 생각합니다. 이건 두배가 되는거예요.
Soo Wo: $7^3$은 343이므로, $7^6 = 7^3 \times 7^3$가 될 것이라고 생각하고, 이것은 343x343 입니다.
선생님: $7^3 \times 7^2$은 어떻게 될 것이라고 생각하시나요?
Molly: 그건 $7^5$과 같아질 거라고 생각해요.
선생님: 그걸 어떻게 알 수 있죠?
Molly: 저는 이미 7의 3승이 343이라는 것을 알고, 7의 제곱이 49라는 것을 알고 있습니다. 그래서 $7^5$은 343x49입니다.
Theresa: 밑이 같은 수를 곱하게 될때, 그들의 지수들을 더할 수 있게 되요. 그래서 $7^2 \times 7^3 = 7^5$ 입니다.
선생님: Theresa가 방금 말한것을 기호를 써서 표현하는 방법이 있을까요?

학생들은 기호로 표현하는 것에 대해서 학습하기 시작한다.

질문들:
1. 발췌문에 대한 전반적인 느낌은 어떠한가요?
2. 두 발췌문에서 선생님이 학생에게 가르치려고 하는것은 무엇인가요?
3. 두 발췌문 사이에서 어떤 유사점이나 다른점이 있습니까?
4. 첫번째 발췌문에서의 선생님의 수학교육 접근법(수학교수법)에 대해서 어떻게 생각하십니까?
5. 두번째 발췌문에서의 선생님의 수학교육 접근법(수학교수법)에 대해서 어떻게 생각하십니까?
6. 한가지 접근이 다른 것보다 낫다고 생각하십니까? 왜 그렇게니까?
7. 선생님이라면 무엇을 다르게 할 것입니까? 왜 그렇게 하려고 할까요?
8. 어떤 방법이 선생님이 가르치는 방법과 비슷한가요? 발췌문에 있는 예나 선생님 자신의 가르침을 잡아가면서 비슷하거나 다른점을 구체적으로 말씀해주세요.
9. 얼마나 자주 이런식으로 가르치십니까? 언제 선생님의 수학교수법이 이런 방식에서 멀어질까? 왜 그렇게니까?
Appendix C

Informed Consent Form

Korean Middle- and High-School Math Teachers’ Understanding of Formative Assessment

Dear Participant,

My name is Sun Hee Lee, a doctoral candidate at the Department of Curriculum and Instruction at the University of Illinois at Urbana-Champaign. You are invited to participate in a research study conducted under the supervision of Dr. Daniel Walsh, a professor in the Department of Curriculum and Instruction at the University of Illinois at Urbana-Champaign.

This is a research study to investigate Korean middle- and high-school math teachers’ understanding of formative assessment. In this interview study, I want to learn about Korean math teachers’ understanding of formative assessment. I am studying formative assessment because Western scholars indicate that it improves teaching and learning. However, little is known about Korean middle- and high-school math teachers’ understanding of formative assessment. Your participation in this study may contribute to current secondary math education literature.

In this study, you will be asked to participate in five semi-structured interviews. Each interview will last approximately thirty minutes. The interviews will be conducted at a time and location of your choosing, most convenient for you. I will space each interview from three days to a week apart. What you share in the interviews will be kept confidential. Prior to each interview, I will ask your permission to audio record your
interviews for transcription purposes so that I can study your responses. I will be transcribing the audio files, and they will not be used for any other purpose.

In addition, I will visit one of your classrooms for an informal classroom observation if you decide to invite me. I will take notes while observing the lesson, but will not record the lesson in any forms (i.e., no audio/video). The notes taken during the observation will be focused on teachers’ instructional practice with regard to formative assessment, and will not be focused on the students.

The minimal risk in this study is no more than what you would ordinarily encounter in daily life or in teaching mathematics in your classrooms. Your identity and your responses shared in the interview will remain confidential. I will use pseudonyms to ensure confidentiality in the final report. The transcripts and the audio files will be kept secure in the College of Education server. Only I have access. However, I will make available your responses to my supervisor since he is monitoring the research. I will send you a summary of your interviews for your review, further input, corrections, and clarification.

Your identity, personal information, and the data collected will be kept confidential and secure in the College of Education server. The data will be destroyed in five years or when a paper is published, whichever is sooner. The result will be published as a doctoral dissertation, journal article, campus and national conferences, and potentially a book for a more general audience. After the study, I will send you an electronic copy of my dissertation.

Your participation in this study is completely voluntary. You may withdraw your participation at any time. Your decision to participate, decline, or withdraw from
participation will have no effect on your status at your school or future relations with the University of Illinois. Please contact Dr. Daniel Walsh (Responsible Project Investigator, RPI) at 217-244-1218 or via e-mail at danielw@illinois.edu with any questions or concerns about the research. You may also call the RPI if you feel you have been injured or harmed by this research. If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Institutional Review Board (IRB office) at 217-333-2670 (collect calls will be accepted if you identify yourself as a research participant) or via e-mail at irb@illinois.edu. Please note that the people answering the phone at the IRB office speak only English.

Sincerely yours,

Sun Hee Lee

Please indicate your consent by signing a copy of this letter and returning it to me. The other copy is for you to keep.

Participant Signature:

Date:

Please also indicate below whether you will permit or not permit the interviews to be audio- recorded for transcription purposes.

☐ Yes, I permit the interviews to be audio recorded.

☐ No, I do not permit the interviews to be audio recorded.
한국 중고등학교 수학교사들의 형성평가에 대한 이해

안녕하세요? 저의 이름은 이선희입니다. 저는 일리노이 대학 (University of Illinois at Urbana-Champaign)에서 박사과정으로 수학교육학을 전공하고 있습니다. 선생님은 일리노이 대학 사범대학의 Dr. Daniel Walsh 교수님의 지도하에 수행되는 연구에 참여하도록 초대되었습니다.

이 연구를 통하여 한국 중고등학교 수학선생님의 형성평가에 대한 이해에 대하여 알아보기로 합니다. 이 인터뷰 연구에서 저는 한국 수학 선생님들의 형성평가에 대한 이해에 대하여 배우고 실습합니다. 서양 학자들에 따르면 형성평가는 교사의 가르침과 학생들의 배움을 향상시킨다고 하여 저는 형성평가에 대하여 연구하고 있습니다. 그렇지만, 한국 중고등학교 수학선생님들의 형성평가에 대한 이해에 대하여서는 연구가 아직 미비합니다.

형성평가가 교수학습에 긍정적인 영향을 미치고 있다는 것은 많이 알려져 있지만 한국의 중고등학교 수학선생님들의 형성평가에 대한 이해와 그것이 어떻게 교사의 가르침과 학생들의 배움에 영향을 미치는지는 아직 연구가 미비합니다. 저는 한국의 중고등학교 수학선생님의 형성평가에 대한 이해를 주제로 하여 인터뷰연구를 하려고 합니다. 선생님이 이 연구에 참여하신다면 현재의 중등 수학교육 학술 연구에 많은 기여가 될 것입니다.

이 연구에서 선생님은 다섯 번의 세미 구조화된 (semi-structured) 인터뷰에 참여를 하도록 부탁드립니다. 각각의 인터뷰는 대략적으로 삼십분이 소요될 것입니다. 인터뷰는 선생님이 정하십니다. 선생님에게 가장 편하신 시간과 장소에서 이루어질 것입니다. 저는 각각의 인터뷰를 3일에서 일주일 정도 떨어뜨려 사이에 휴식을 두려고 합니다. 선생님이 인터뷰에서 공유한 내용은 비밀로 지켜질 것입니다. 첫번째 인터뷰가 시작되기 전에 저는 선생님의 인터뷰를 전자 (transcription) 목적으로 음성녹음을 할 수 있을지 선생님의 허가를 받도록 할 것입니다. 음성 녹음 파일은 제가 전사를 할 것이며, 음성녹음을 전사되어진 내용은 저의 연구이외에 다른 어떤 목적으로도 사용되지 않을 것입니다.

여기로 덧붙여서, 만약 향후에 저를 선생님의 수업에 초대해주신다면 수업을 참관하도록 하겠습니다. 수업을 참관하는 동안 노트를 적을것이지만, 수업을 오디오나 비디오로 녹음을 하지는 않을 것입니다. 수업참관 중에 적을 노트는 선생님의 형성평가에 관한 교수방법에 초점을 돌것이며, 학생들에게 초점을 두지 않을 것입니다.

이 연구에 참여함으로써 예상되는 최소한의 위험이 일상적인 생활에서 일반적으로 맞닥뜨리는 것, 또는 수업에서 수학을 가르치는 것보다 정도가 크지 않습니다. 선생님의 신분과 인터뷰에서 공유하신 선생님의 답변은 비밀로 할 것입니다. 마지막으로 보고서 (박사논문)에는 선생님의 이름을 가명으로 하여 비밀을 보장할 것입니다. 전사되어진 파일과 음성파일은 사범대학 서비내에 안전하게 보관할 것입니다. 그곳에는 저만 접근이
가능합니다. 그러나, 저의 연구 감독 교수님이 저의 연구를 감독하시기 때문에 선생님의 답변을 저의 연구 감독 교수님이 보실 수 있도록 할 것입니다. 선생님과의 인터뷰 요약문을 보내드릴 것입니다. 선생님의 제의를, 추가적인 사항, 정정 사항, 부연설명을 제공하여 주시면 감사하겠습니다.

선생님의 신분, 개인정보, 그리고 인터뷰 중 얻어진 자료는 비밀이 지켜질 것이며, 사법대학 졸매에 안전하게 보관할 것입니다. 데이터는 연구가 끝나고 5년 후, 또는 연구 결과가 출간이 되어지면 바로 파기할 것입니다. 연구 결과는 박사 논문, 저널 논문, 교내 외 국제적인 컨퍼런스, 그리고 조금 더 일반적인 독자를 위한 책의 형식으로 출판될 것입니다. 연구가 끝나면 저의 박사논문의 전자파일을 보내드리겠습니다.

선생님의 이 연구에 대한 참여는 철저히 자발적인 것입니다. 선생님은 어느 때고 참여를 철회하실 수 있습니다. 선생님의 참여할 결정, 거부할 결정, 또는 참여를 철회할 결정은 선생님 학교에서의 현재 지위 또는 일리노이 대학과의 미래 관계에 어떤 영향도 미치지 않을 것입니다. 이 연구에 대한 질문이나 결정사항이 있으시다면 Dr. Daniel Walsh 교수님 (Responsible Project Investigator, RPI) 을 전화로 217-244-1218 혹은 이메일로 (danielw@illinois.edu) 컨택하시기 바랍니다. 또한, 이 연구로 인해서 다치거나 해를 입었다고 생각되신다면 RPI 에게 전화 또는 이메일로 연락하시기 바랍니다. 이 연구의 참가자로서 선생님의 권리에 대한 질문사항이나 결정거리 또는 불만사항이 있으시다면 일리노이 대학의 기관윤리심의위원회 (University of Illinois Institutional Review Board, IRB) 에 문의 (217-333-2670)또는 이메일 (irb@illinois.edu)을 하시기 바랍니다. 기관윤리심의위원회에서 전화를 받는 분은 영어만 쓸 수 있습니다. 이전회 올림
이 편지의 사본에 사인을 하시고 저에게 주심으로써 선생님의 이 연구에 대한 동의의 의향을 알려주시기 바랍니다. 다른 사본은 선생님께서 보관하시기 바랍니다. 참가자 사인:

다음에, 인터뷰가 전사목적 (transcription purpose)으로 응성녹음을 될 것을 허락하는지 허락하지 않는지의 여부에 대하여 밑에 표시하여 주시기 바랍니다.

☐ 니, 인터뷰가 응성녹을 되는 것에 대하여 허락합니다.

☐ 아니오, 인터뷰가 응성녹음을 되는 것을 허락하지 않습니다.