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# Impact of Video Case Studies on Elementary Mathematics Teachers' Ways of Evaluating Lessons: An Exploratory Study

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**Abstract:** This paper explores the impacts of using video cases on in-service teachers' ways of evaluating mathematics lessons in China. Sixteen elementary mathematics teachers participated in a video case-based, 5-day training program. Based on data analysis of questionnaires, interviews, and video-clips collected over the 5-day program, we found that participating teachers shifted their evaluation perspectives from focusing on general pedagogical facets to balancing mathematical content and pedagogical content. In addition, the participants perceived positive impacts of the video case-based training program on their understanding of pedagogy and their abilities in evaluating lessons and reflecting upon their practice.

**Key words:** Chinese teachers; Video cases; Professional development; Evaluation of mathematics instruction

## Introduction

Since the implementation of the new mathematics curricula in China in 2001(Ministry of Education [MOE], 2001), mathematics educators and teachers in China have faced various challenges in implementing curricular changes in classroom instruction (Liu & Li, 2010). Grounded in the tradition of teaching research and supported by multimedia technology, an innovative approach to teacher professional development called Action Education Research has been developed and popularized recently in China (Gu, 2003; Huang & Bao, 2006). One

important element of this approach is to make hypermedia video cases that show essential components of developing an exemplary lesson. This has resulted in a large number of video cases made by teachers and teaching researchers based on their joint efforts to develop exemplary lessons (Bao & Huang, 2007; Huang & Li, 2009).

Video case studies have been proposed as a tool for teacher learning because they provide an authentic and reliable classroom teaching situation, multiple representations, and an opportunity to learn from experts (Bao, Wang, & Gu, 2005; Borko, Jacobs, Eiteljorg, & Pittman, 2008). Consequently, video cases have been widely used in teacher education programs (e.g., Alsawaie & Alghazo, 2010; Seago, 2004; Star & Strickland, 2008). Several research studies have focused on how video cases can be used particularly to foster teacher professional development (Borko et al., 2008; Lin, 2005; Perry & Talley, 2001; Sherin & Han, 2004; Sherin & van Es, 2005, 2009). For example, Perry and Talley (2001) emphasized that experts' and teachers' reflections included in video cases can help in-service teachers nurture their habit of reflecting on their own practices. In addition, studies have found that using clips from video cases can foster productive discussions (Borko et al., 2008), analysis of lesson components (Alsawaie & Alghazo, 2010), development of noticing ability, and professional vision (Sherin & van Es, 2005, 2009). However, little is known about the extent to which video case studies can impact teachers' abilities to evaluate lessons and critically reflect on their own practice. These abilities and skills are crucial for in-service teachers' continuing professional development (Artzt, Armour-Thomas, & Curcio, 2008).

By using extant video cases that were developed according to a model proposed in Action Education Research, we conducted a summer teacher training program to explore how in-service teachers may change their ways of evaluating mathematics lessons and reflecting on their own lesson designs. The video cases in this study, called hypermedia video-cases, aimed at providing a learning environment that integrated lesson video clips, case questions, comments on the lesson from experts, peers and students, and other related resources (Bao et al., 2005). In particular, we aimed to address the following research questions:

(1) Did the participant teachers demonstrate the new ways of evaluating mathematics lessons advocated by the program after participation in the program?
(2) What were the participant teachers' perceptions of the effects of the video case-based training program on their professional learning?

## Literature Reviews and Theoretical Considerations

### *Video Case Studies and Teachers' Learning*

Studies over the last two decades have promoted the use of video case studies for professional development purposes and identified key aspects of its use with in-service teachers. Given the complexity of teachers' knowledge for teaching, several studies have recommended that teachers' learning should be contextually situated and case based (Aamodt & Plaza, 1994; Ball, Sleep, Boerst, & Bass, 2009; Shulman, 1996). In addition, researchers have concluded that teachers' learning could be enhanced by repeatedly using a situation or case at various times for different purposes (Spiro, Feltovich, Jacobson, & Coulson, 1991); and case studies can help teachers make teaching visible and easy to understand, as well as promote their abilities to reflect on their own practices (Merseth & Lacey, 1993). In the field of mathematics, researchers have suggested that through crossing the generality of theory knowledge and the particularity of a situation, case studies provide a way for teachers to build useful and suitable knowledge to promote teaching and learning mathematics (Cannings & Talley, 2002; Stein, Smith, Henningsen, & Silver, 2000).

Researchers found that using video case studies has the potential to change teachers' noticing of classroom events and professional version (Sherin & van Es, 2005, 2009) and their ways of analyzing teaching (Alsawaie & Alghazo, 2010). For example, Sherin and van Es (2005) found that after viewing a selected clip, facilitated by a discussion of the ways to notice events, the participants showed significant changes in noticing from what the teacher was doing to what the students were saying. The findings suggested that, through effective discussions, both experienced and inexperienced teachers can change what they notice in videos of teaching. In addition, Alsawaie and Alghazo (2010) concluded that prospective teachers can improve their ability in analyzing teaching through video-based approach. Moreover, Star and Strickland (2008) called for a deliberate organization of discussion problems during the process of using video cases to enhance participants' ability to notice classroom events.

### *Mathematization as the Underpinning of Video Cases*

A model for developing video cases was recommended by researchers in China (Bao et al., 2005) for enhancing professional development. According to this model, a video case should include two parts. One is the main body of the case that includes a case discussion worksheet, video clips, case questions, and case evaluations. The second component is a case resource bank that includes relevant websites, research, and teaching materials. All the components can be activated by using electronically linked "hot" buttons in the computer software.

In our study, we selected three video cases made by following the Bao's et al. model (2005) to prompt teachers' learning through a video case-based teacher training program. The video cases focused on three core aspects of elementary mathematics: *division with remainders, the concept of fractions,* and *problem solving in daily life contexts.* In addition, *mathematizing* was an overarching teaching and learning principle for the development of these video cases. According to Freudenthal (1991), mathematics starts within common sense and develops from informal to formal mathematics reasoning. The formal mathematical reasoning refers to a form of reasoning that builds on arguments located in the newly formed mathematical reality. *Mathematization* is a fundamental process of mathematics teaching and learning (MOE, 2001; National Council of Teachers of Mathematics [NCTM], 2000).

Compared with expert teachers, novice teachers quite often pay too much attention to the forms of classroom activities and classroom management rather than focus on the development of mathematics content and mathematical thinking (Huang, Li, & He, 2010). In the program used for the present research, the main focus was to draw teachers' attention to developing mathematics concepts and *mathematizing* processes through specific interventions.

***A Framework for Capturing Teachers' Changes***

As argued by Mason (1998), it is a crucial step to develop teachers' awareness from awareness-in-action to awareness-in-discipline. *Awareness-in-action* refers to the powers of construal and of acting in the material world. For example, someone can add, subtract, and/or multiply without being explicitly aware of any awareness-in-action of numerals, place-value, routines, the role of order, etc., that make the arithmetic possible. *Awareness-in-discipline* is the sensitivities that enable us to work with students in a mathematically informed and appropriate fashion. In the current study, by using the deliberately selected video case, the program intended to help participants increase their awareness-in-discipline when evaluating a lesson. After watching lessons taught by expert teachers and listening to comments by researchers and teachers included in the video cases, the participants were organized to compare their own designs and the demonstrated video-taped teaching, to determine how a topic could be taught through mathematizing processes. The discussion was guided to focus on two aspects: (1) accurate understanding of mathematics contents, and (2) effective development of the contents through mathematically worthwhile activities.

By considering the classifications of teachers' knowledge (An, Kulm & Wu, 2004; Hill, Schilling, & Ball, 2004; Shulman, 1986), we examined the emerging patterns of teachers' attention to mathematics content (MC), general pedagogy (GP), and

pedagogical content (PC) when evaluating lessons. *Mathematics content* (MC) refers to procedural and conceptual knowledge; *general pedagogy* (GP) consists of goals and objectives, selection of tasks and representation, motivation of students, connectivity and sequencing of display and so on; and *pedagogical content* (PC) means building on students' mathematics ideas, addressing students' misconceptions, engaging students in mathematics learning, and promoting students' thinking about mathematics.

## Method

### *Participants*

Sixteen mathematics teachers from elementary schools volunteered for a video case-based elementary mathematics teacher's training program organized by a university in South China. Two of the participants were male and 14 were female. Eight of the participants had a diploma in primary education and the others had a bachelor's degree or master's degree (none of them specializing in mathematics education). Their teaching experience averaged six years, ranging from 2 years to 20 years.

### *Intervention Video Cases and Organization*

*(1) Organization of the Program*

This summer program included five three-hour workshops. They were: (1) introduction to video case studies; (2) video case studies on teaching division with remainders; (3) video case studies on teaching the concept of fractions; (4) teaching of a paper-folding problem; and (5) evaluating video-taped lessons of teaching decimals. The first two video cases (division and fractions) had received awards from the China Teacher Education Association in 2004. The third video case (paper folding) was developed by the researchers in a school-based teaching research project, and the fourth one (decimals) was a public lesson demonstrated at a regional mathematics education conference in Macau, China in 2005.The teaching objectives and teaching procedures of the first, second, and fourth video-taped lessons are listed in Table 1. From the teaching objectives and teaching procedures identified in the table, it is possible to determine that all the video cases were aimed at reflecting the *mathematizing process*: formulating mathematics concepts based on daily life situation exploration.

Table 1
*Teaching Objectives and Teaching Procedures of Three Video-taped Lessons*

| | Topic A: Division with remainders | Topic B: Fractions | Teaching of decimals |
|---|---|---|---|
| Teaching objectives | 1. Understand the meaning of "remainder".<br>2. Understand why "remainder is definitely less than divisor".<br>3. Get an experience of "elementary mathematics is part of a child's daily life experience". | 1. Understand the meaning of "half".<br>2. Understand the meaning of fraction.<br>3. Get an experience of the close relationship between fractions and daily life. | 1. Understand the meaning of decimals.<br>2. Master how to write and read decimals.<br>3. Understand the relationship between decimals and fractions.<br>4. Apply decimals to contextual problems. |
| Teaching procedure | 1. Through the "distributing beans" activity, students were led to understand "division means distributing beans"; "The number of beans placed in plates is the trial quotient" and "the number of remaining beans is less than the number of plates" implies "the remainder is smaller than the divisor".<br>2. Through "distributing beans in minds instead of using beans and plates" students were forced to transfer from hands-on activity to formal operations which can be presented in multiple representations (equation form, column form, and word expression)<br>3. Sharing learning experience. | 1. Through exploring "distributing cakes", halving concept was introduced<br>2. More activities were explored to formalize the fraction through multiple representations: iconic and symbolic representation. Then the teacher formally explained the meaning of 1/2 with the example of dividing a cake.<br>3. More problems and activities were explored for clarifying and abstracting concepts.<br>4. Summary and homework. | 1. Through demonstrating different food prices, several integers and decimals (e.g., $3, $5.4, $2.68) were expressed, and their reading methods were introduced.<br>2. Students were requested to discover the relationship between integers and decimals.<br>3. The reading of dollar, cent, and decimals (13 dollars and 42cents, $13.42) was further discussed.<br>4. Decimal applications in daily lives were discussed.<br>5. Summary and homework. |

In the first workshop, the advantages of using the video case as a tool for in-service teacher education were introduced. The underlying teaching principle of these video cases, *mathematizing*, was highlighted. Three topics were then assigned to four, four-person groups (i.e., G1, G2, G3, and G4). Each group was formed according to participants' convenience. Two groups (G1 and G2) selected Topic A: teaching of division with remainder; one group (G3) selected Topic B: teaching of the concept of fractions and the remaining group (G4) selected Topic C: teaching of the paper-folding problem (not shown in Table 1). Each group was invited to design a lesson plan of the selected topic for leading the discussions in the follow-up workshops.

Workshops 2 to 4 included similar phases: (1) discussing the participants' own designs (prepared by one or two groups), presenting and discussing pre-lesson questions (focusing on mathematics content aspects, and mathematics pedagogical knowledge); (2) watching an entire video-taped lesson taught by an expert teacher, and presenting and discussing post-lesson questions; (3) listening to the comments from the acting teacher, students and experts or researchers included in video cases; and (4) reflecting on the differences between participants' design and the teaching demonstrated in the video cases, and summarizing what they had learned. The main purpose of these workshops was to develop participants' abilities in posing and discussing questions from the perspectives of mathematics contents and mathematics pedagogical knowledge, with particular attention to the *mathematizing process* in these lessons.

In the last workshop, a video-taped lesson on teaching of decimals was used for participants' discussion and evaluation. Each group sent a representative to present the group's opinions. The articulation was used to gauge possible changes in the participants' ways of evaluating lessons when compared with their first video case discussion. All five sessions were videotaped.

*Intended Ways of Evaluating Lesson*s

In the second workshop, the video case, *teaching division with remainder*, was used to demonstrate what mathematizing is and how to implement the *mathematizing* principle in classes at the elementary school level. The video case demonstrated the following key points:

(1) the meaning of mathematizing,
(2) the difficulties in teaching division with remainder, and
(3) an innovative design to teach division with a remainder.

The video case used in the third workshop was about the introduction to fractions. First, a design of teaching this topic was introduced by one group (G1). Based on

the discussion of the initial design by the group, the facilitators posed several pre-lesson questions soliciting participants' further discussion. For example, the pre-lesson questions of this video-taped lesson included:

(1) how many ways can you figure how to partition a rectangle into two equal parts?
(2) what kinds of knowledge do you think students may have about fractions such as $\frac{1}{2}$?

Following this activity, an exemplary video-taped lesson included in the video case was played for participating teachers to watch and comment in groups. Then, the participants watched the comments on the lesson from experts, teachers, and students included in the video case. Finally, the facilitators gave some post-lesson questions for further discussion that resulted in a summary. For example, the following two post-lesson questions were discussed:

(1) what do you think about the relationship between a fraction and a decimal?
(2) which of fraction or decimal should be taught first for enhancing students' learning?

## Data Collection

To answer our research questions, we used a questionnaire, interviews, and video taping of professional learning sessions to gather data about participants' perception of the effects of the video-based program and approaches to evaluating lessons.

### *Questionnaires*

In the final session, we conducted a researcher-designed survey with the 16 participants. The survey asked the participants to identify their background characteristics (gender, age, teaching experience, highest education degree, etc.) and to rank on a 4-point scale their perceived effects of the video case-based training program: no experience (score 1), not important (score 2), somewhat important (score 3), or very important (score 4). The perceived effects on the teachers' learning included: (a) deepening understanding of mathematics content, (b) deepening understanding of mathematics thinking, (c) updating the notions of education and teaching, (d) applying theories of mathematics teaching/learning to classroom practice, (e) advancing the ability in lesson designing and delivering, (f) enhancing the ability in flexible analysis of lessons, (g) promoting the ability in reflecting on teaching mathematics, and (h) promoting the awareness of reflection

on and improvement of lessons. All the participants completed the survey and returned the survey on site.

***Interview***

After completion of the program, three teachers were purposely selected for individual interview (i.e., T1, T2 and T3 in this paper) on the basis of their willingness to share with others during the program. The purpose of this interview was to investigate their perceptions of and comments on this program, with a focus on the differences between their own evaluation of classroom teaching and the expert perspectives articulated in the video cases. The teacher interview was guided by the following questions: (a) Compared to your own teaching design, how did the video cases differ? What are the implications of the video cases for your learning? (b) Compared to traditional teacher training programs, how were the main characteristics of this program different from traditional ones? (c) What are your suggestions for the improvement of video case-based teachers' training programs? A research assistant interviewed all the three teachers in approximately 45 minutes each and the interviews were audio recorded for later analysis for triangulation of participants' perceived effectiveness of the program.

***Video-taping the Ways of Evaluating Lessons***

We videotaped all the sections of the summer workshop. In two sections, the videos were selected for examining teachers' changes of their ways of evaluating lessons. In the first section, participants' discussions of the video case of teaching division with remainder were used to examine pre-existing approaches to evaluating lessons. In the last section, the discussions based on watching video-taped lesson of decimals were used to examine the changes in approaches to evaluating lessons.

## Data Analysis

***Pre-existing and Changed Approaches to Evaluating Lessons***

The video clips of the participants' discussion and sharing in the two selected sections were transcribed. The first one (earliest) was referred to as the pre-intervention section while the second one was designated as the post-intervention section. The transcripts were analyzed by using the framework of attended aspects: mathematical content knowledge (MC), general pedagogy (GP), and pedagogical content (PC) to capture the features of these teachers' approaches to evaluating lessons. The coding process was conducted based on video transcripts in Chinese. The process involved the first author separating the transcripts into segments that included a focused and clear theme. Then, each segment was classified into one of the pre-determined three categories, i.e., MC, GP, and PC. The first author and a

research assistant coded these segments separately as a means of establishing inter-rater reliability. The inter-rater agreement was around 86%, and disagreements were resolved through discussions between the first author and the research assistant. The codes and relevant examples are listed in Table 2.

Table 2
*Dimensions of Evaluating Mathematics Lesson*

| **Dimension of Evaluation** | **Example** |
|---|---|
| Mathematics content (MC) | We think that when the teacher teaches decimals, she only emphasizes that the left side of the decimal point is integer and the decimal point is at the right lower corner. Then can this help the students understand about the relationship of the formations of decimals? [Post-intervention section_G3] |
| General pedagogy (GP) | The students first divided beans with their plates to get a vivid experience of the concept, and then they did the operations in mind after taking away all the plates. Finally, the formal expression of division with remainder was introduced. This process is from concrete to abstract. [Pre-intervention section_G2] |
| Pedagogical content (PC) | Teacher introduced $0.1=\frac{1}{10}$ by explaining that "ten cents equal one tenth of a dollar." Then students may be confused if converting decimals into fractions must be related to dollars. [Post-intervention section _G3] |

For example, one group (G2) commented on the video-taped lesson on division with remainder as follows:

> The students first divided beans with their plates to get a vivid experience of the concept, and then they did the operations in mind after taking away all the plates. Finally, the formal expression of division with remainder was introduced. This process is from concrete to abstract.

This segment was coded as general pedagogy (GP) because these comments were concerned with how the teacher helps students to develop the algorithm through selecting different activities and multiple representations.

## Results

The results are organized into two parts to answer the research questions respectively. First, the changes of participants' ways of evaluating lessons are reported. Then, the participants' perceived effects of the video case-based program are described.

### *Change in Approaches to Evaluating Lessons*

*(1) Pre-existing Approaches to Evaluating Lessons*

Based on the discussions of (1) the strong points and disadvantages of the lesson of teaching division with remainder (pre-intervention), and (2) post-lesson questions about mathematics content and mathematical pedagogy, we identified the main themes of participants' attention. They included general pedagogy (GP) and pedagogical content (PC). The following points were mentioned with regard to GP: (1) emphasizing student's self-directed learning, sharing, and summarizing, (2) organization and delivery of the lesson, (3) motivation dealt with inappropriately, (4) lack of summary and proper classroom exercises, and (5) need for wider student engagement. Other points were referred to as PC: (1) emphasizing the process of mathematizing from concrete manipulation to abstract concept or procedure, (2) students' discovery of the meaning of division with remainder, and (3) symbolic representations of the algorithm. For example, some groups focused on pedagogical content such as building on students' mathematics ideas as shown in the following excerpt:

> Students were asked to explain why the algorithm works rather than completing the algorithm procedurally by paper and pen. And students were required to think and operate in their minds. In addition, the conclusions were made by students. We believe these teaching strategies are helpful. (G1)

For another example, some groups made the following positive comments on the lesson with regard to tasks and presentations (GP) as follows:

> The students first divided beans with their plates to get a vivid experience of the concept, and then they manipulated in mind after taking away all the plates. Finally, the formal expression of division with remainder was introduced... At last, the teacher used magnetic beans and plates to help students understand the relationship among the dividend, divisor, and remainder. That is really helpful. (G2)

In addition, the students' engagement and the teacher's questioning skill (GP) were appreciated as follows:

> I think they [students] may have better thinking ability or it may depend on teacher's good questioning skills [to get students engaged in the discussion]. After manipulation activity, the teacher asked students what secrets you may find. To answer this question, the students have to think and reflect what you observed in depth. I think it is quite good questioning. (G1)

In summary, during the discussion, the participants mainly focused on general pedagogy (GP), with less attention to the pedagogical content (PC).

*(2) Changed Approaches to Evaluating Lessons*

Based on the transcripts of discussion and sharing in the last workshop, we identified the following features of evaluating the lesson. The participants paid much more attention to the process of *mathematizing* (PC) and mathematical content understanding (MC) than general pedagogy (GP). The main themes were illustrated by the following sections.

*Inappropriateness of using daily life situation.* Although the efforts to introduce the concept of decimals using various daily life examples included in the video were appreciated (PC), the participants criticized the appropriateness of using these contextual examples. For example, one group raised its concerns as follows:

> Our group thought that this lesson does not reflect mathematizing. It is so emphasized on context that the students may not be able to read decimals without dollars. (G1)

*Proper use of students' experience and ideas.* The participants challenged whether or not the students' daily life context was properly used, and the students' knowledge prerequisite was associated effectively (PC). These concerns are illustrated in the following episodes:

> She should clearly explain the relationship between fraction and decimal. Since she does not explain clearly why one over ten is equal to zero point one, the students may not accept it. The teacher does not apply the *mathematizing* principle well. I think she specially gives some examples about daily life situations, and then asks students to find where they can see decimals in daily lives. In fact, the students still are not clear where the decimals can be applied to. (G1)

*Lack of understanding of connotation of mathematics concept*. The teacher was criticized for not paying due attention to the understanding of the concept of the decimal itself (MC). The following excerpts explain these concerns:

> Three dollars and fifty cents [can be presented as] three point five dollars. It is very simple. It is good that mathematics can simplify some expressions. Can we write one hour and thirty minutes as one point three zero hour? Why can't we write it in this way? This is a sixty-base system, so it can't be written in this way. (G4)

> The teacher introduced that whenever it is something over ten [e.g., $\frac{3}{10}$ ], it is equal to zero point something [e.g., 0.3]. However, if it is eleven over ten [e.g., $\frac{11}{10}$ ], how can we tell the students it is equal to zero point eleven [e.g., 0.11]? It is incorrect [of conceptual understanding]. (G2)

In summary, when evaluating this lesson, the participants mainly focused on the mathematical correctness of the concept (MC), appropriateness of the daily context, and effectiveness of the mathematizing process (PC), with less attention to general pedagogy (GP).

*(3) Perceived Effects of the Video Case-based Training Program*
Perceived effects of the video case-based program were manifested in the participants' self-evaluations and interviews.

*(4) Self-Evaluations of the Effects of the Program*
The average scores of participants' self-evaluation on the effects of the video case-based training program are shown in Table 3 (0–4 point scale).

Table 3 shows that the participants believed that the video case-based training program was very important (3.75) in deepening understanding of mathematics content and deepening understanding of mathematical thinking. They felt this kind of program was helpful for promoting the awareness of reflection and improvement (3.63), applying mathematics teaching/learning into classroom practice (3.56), and promoting reflecting ability in teaching mathematics (3.56). In addition, the video case-based program also had a positive influence on teachers' updating of instructional notions, improving instructional design, and fostering flexible reflection abilities (around 3.4).

Table 3
*Self-evaluations on the Effects of the Video Case-based Program*

| Item | Mean |
|---|---|
| Deepening understanding of mathematics contents | 3.75 |
| Deepening understanding of mathematical thinking | 3.75 |
| Updating the notions of education and teaching | 3.40 |
| Applying mathematics teaching/learning theories to classroom | 3.56 |
| Advancing the ability in lesson design and delivery | 3.50 |
| Enhancing the ability in flexible analysis of lessons | 3.38 |
| Promoting ability in reflecting on mathematics teaching | 3.56 |
| Promoting the awareness of reflections and improvements | 3.63 |

*(5) Perceived Effects of the Program through Interview*
During interviews, the three teachers further expressed their perceptions of what they had learned through participation in this program.

*Learning the feasible ways of mathematization.* Mathematizing emphasizes the process of concept formation, which begins with manipulation of concrete objects and then forms mathematics concepts progressively. Although the mathematizing process was ignored in traditional teaching, the creative design of the video cases exhibits the mathematizing process vividly. These points were expressed by some interviewees as follows:

> In our own design, we mainly designed the lesson based on our previous experience, with a close attention to active teaching. We did not know the mathematizing process at all. Through watching video cases, we not only understand the mathematizing principle, but also learned different strategies to implement this principle. We need to strengthen this aspect. (T2)

*Searching for good practice through watching others' teaching.* By comparing participants' original designs at the beginning of the program (or in their past teaching) with the videotaped lessons shown in the case-based program, teachers were able to identify their shortcomings and find alternatives to improve their own practices. One teacher indicated:

> We begin to understand why we should watch how other teachers teach. This is because we can reflect on how we can do better in our own lessons through watching others' teaching! (T1)

*Enhancing the reflection ability through seeing the same situation from multiple perspectives.* Through repeatedly watching video clips and listening to the comments from different people such as experts, teachers, and students, the teachers were able to see and hear different points of view about the same issue. They indicated that the experts' comments were especially helpful for enhancing reflection ability.

> Personally, I like to watch some experts' comments, or some experienced teachers' comments. Due to their plentiful experience, they can provide a deep analysis. (T3)

With all elements considered, the video case-based program appeared to help participants to update certain instructional ideas such as mathematizing, developing their abilities in evaluating lessons, and reflecting on their own practice.

## Discussion and Conclusion

Based on the previous analysis, the following conclusions are made about the impacts of the video case-based professional development program on elementary mathematics teachers' learning. First, the teachers' paradigms of evaluating a lesson seem to change from focusing on general pedagogy and somewhat on pedagogical content to balancing mathematical content and pedagogical content perspectives. It is crucial for teachers to pay attention to developing mathematics concepts through worthwhile activities when implementing various reform-oriented teaching strategies. Second, participants understood and valued the mathematizing process for improving mathematics teaching and found that analyzing a lesson from different perspectives fostered their reflection ability, and comparing different designs and practices benefitted and led to their improvement of teaching. Third, the video case-based training program had the additional positive effects including: (1) improving participants' understanding of particular mathematics content and pedagogy; (2) advancing their ability in evaluating lessons and reflecting on their own practice; (3) enhancing the awareness of analyzing their lessons and reflecting on their practice through problem posing and solving.

This study supported the proposition that using video-case studies can change teachers' ways of viewing classroom events (Sherin & van Es, 2005, 2009) and their paradigms of analyzing lessons and reflecting on their own practice (Alsawaie & Alghazo, 2010; Cannings & Talley, 2002). This study also provided a feasible way to advance teachers' awareness-in-discipline, which is closely related to expertise in teaching (Mason, 1998).

In addition, this study provides insights into the quality of video cases which creates or constrains the learning opportunities of video-based teacher education programs. Unlike other studies (e.g., Sherin & van Es, 2005, 2009), the video cases used in this study represent an integration of exemplary lessons taught by expert teachers, as well as comments from researchers and experienced teachers based on the process of developing exemplary lessons (Bao et al., 2005; Bao & Huang, 2007). Moreover, all the selected video-taped lessons share the same teaching principles of the *mathematizing process*. As the study shows, to maximize teachers' learning opportunities, it is fundamental to use research-based, interactive video cases that demonstrate exemplary teaching with multiple perspectives provided on analyzing the lesson from the teacher who taught the video-taped lesson and experts who commented on the lessons. Meanwhile, the use of video cases should draw participants' attention to discussing essential aspects of mathematics teaching (such as mathematics content and mathematical pedagogy) and developing their reflection ability.

This study has some limitations. The small sample and short-term program reduces the generality of the research findings. As the video-taped lessons used for pre-intervention and post-intervention examination were not the same, the specificity of the content may have impacts on participants' discussion of the lessons. Cautions should be taken when interpreting the findings of this study due to these limitations.

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