Journal of Mathematics Education
December 2014, Vol. 7, No. 2, pp. 16-29

Laboratory Class Cycle: A Model for Teacher Development

Lu Pien Cheng
National Institute of Education, Singapore
Ho Kyoung Ko
Graduate School of Education, Ajou University, Korea

Continued learning is vital to effective teaching. The present paper reports on a case study which explored the affordances of the laboratory class cycle as a structure for anchoring elementary mathematics teachers' continual learning about teaching. The laboratory class is a teaching cycle that engages teachers in the preparation, observation and critique of mathematics lessons. Six teachers and one administrator who worked closely with the teachers in an elementary school in the south eastern region of the United States participated in the study. Interviews were conducted with all the participants to elicit the value they attached to the laboratory class cycle. Findings showed that each of the three components in the laboratory class cycle assisted the participants in their learning to teach.

Key words: *Teacher development, learning community, professional development, mathematics lessons*

One of the main goals of mathematics focused professional development programs is to provide teachers with updated and new information related to the teaching of mathematics. As such, most professional development programs focus directly on the techniques or knowledge necessary for teaching with topics ranging from how children learn mathematics to learning about different curricula. Dewey (1944) argued that professional development programs should not only present new knowledge and techniques but should also enable teachers to grow intellectually by promoting reflective thinking among them. That is, efforts should aim at enabling teachers to make sense of their current situation whilst empowering them to develop skills that would allow them to deal with challenges that might arise in future teaching. Numerous studies have revealed how teachers reflect and ruminate on their own teaching practice and make improvements in light of such reflection (e.g., Crotty & Allyn, 2001; Freeman & Richards, 1996; Lee, 2012; Park, Han, & Lee, 2008; Shrum & Glisan, 2005; Wolfensberger, Piniel, Canella, & Kyburz-Graber, 2010).

Wilson and Berne (1999) examined the research literature on contemporary professional development initiatives and reported that effective programs tend to involve teachers in communities of practice which

encourage examining issues of practice as a learning team. Consensus exists that productive professional development efforts are school based (Hawley & Valli, 1999, Smith, 2001; Demulder & Rigsby, 2003) and job embedded. There is also agreement that "opportunities to shift the emphasis of school-based consultation from addressing problems toward developing consultee skills, knowledge, and confidence toward a more positive and preventive model" (Truscott & Truscott, 2004, p.51). Studies have been reported on how communities of practice are built and what teachers gain from participating in them (Grossman, Wineburg, & Woolworth, 2001; Gutierrez, 2000; Little, 2002; Palinscar, Magnusson, Marano, Ford, & Brown, 1998; Sztajn, Hackenberg, White, & Allexsaht-Snider, 2007). Less obvious however, is how teachers cope with changes while engaged in such communities.

Review of Literature

Teachers experience difficulty in applying what they learn in professional development sessions to actual teaching practice if these initiatives that do not take into account their current and future experiences with students, i.e., their teaching practices. Teacher education frequently focuses its attention on what teachers need to know and how they should be trained (Carter, 1990). This paradigmatic mode of thought has been criticized suggesting that attempts to form relevant knowledge through experience and understanding should become the forefront (Eisner, 1988). This view is consistent with Dewey's interpretation of education as described below.

Dewey defined education as the "continuous reconstruction of experience" (1944, p. 80). He elaborated that "Reflection is that process of reconstruction and reorganization of experience which adds to the meaning of experience" (Rodgers, 2002, p. 848). Dewey did not view education and reflective thinking as significantly different from another. He equated education with improving reflective thinking and a process that reorganizes meaningful experiences. The goal is to ignite anticipation for new experiences while grounding decision making in drawing on practice and self-examination. Roderges (2002) articulated this as "the growth of a teacher may well pass from self-absorption, to forgetting oneself, to self-awareness (observing and reflecting upon his or her actions, thoughts, and emotions), as the reflective practice evolves" (p. 860). Feiman-Nemser (2001) used the assisted performance model to lay out a continuum of teacher learning. The author identified four tasks central to the effective professional development programs for teachers:

> Extend and deepen the subject matter knowledge necessary for one's teaching; Extend and refine one's repertoire in curriculum, instruction, and assessment; Strengthen the skills and dispositions necessary to study and improve teaching; Expand responsibilities and deepen leadership skills (p. 1050).

Mewborn and Stinson (2007) also used the assisted performance metaphor in their analysis of teachers' learning to examine the interplay among novice teachers' personal theories, their mathematics education coursework, and their field experiences. Dewey (1944) proposed that improving reflective thinking requires scientific and systematic processes, and he proposed a five-stage method to achieve such a purpose:

> First, having a genuine situation of experience; secondly, that a genuine problem develop within this situation as a stimulus to thought; third, that he possess the information and makes the observations needed to deal with it; fourth, that suggested solutions occur to him which he shall be responsible for developing in an orderly way; fifth, that he has opportunity and occasion to test his ideas by application, to make their meaning clear and to discover for himself their validity (p. 163).

Rogers (2002) illuminated on Dewey's stages: "first, An experience; secondly, Spontaneous interpretation of the experience; third, Naming the problem(s) or the question(s) that arises out of the experience; fourth, Generating possible explanations for the problem(s) or question(s) posed; fifth, Ramifying the explanations into full-blown hypotheses; sixth, Testing the selected hypothesis " (p. 851).

Knowledge is organized and restructured when personal experiences and their meanings are related and communicated with others. In other words, knowledge is reassembled both individually and collectively when people exchange their conclusions and narratives with others (Olson, 1995). Teachers form their mathematical knowledge through personal experiences while engaged in practice. While reflecting on practice while engaged in practice may be difficult to do, reflection on practice can serve as a powerful vehicle for learning. Hence, the essence of teaching lies in the growth of reflective thinking in and on practice. In this study, Laboratory Class model was used as a means to facilitate reflection among teachers.

Laboratory Class Cycle

In this study, we used a laboratory class cycle to encourage the teachers to try out different teaching approaches as they interacted with students. A laboratory class as a teaching cycle consists of three components: preparation, observation and critique of mathematics lessons. "The laboratory class cycle has the same structure of investigation (planning, research lesson and reflection) as the lesson study cycle Lewis, Perry, & Hurd, 2009) except that in the laboratory class cycle, the lessons are not repeated" (Cheng, 2014, p. 134).

In this study the authors served as professional development providers. Their roles were to facilitate and support the teachers' learning in the preparing, observing, and critiquing of mathematics lessons. They also taught lessons in classrooms to provide teachers with opportunities to experience

exemplary practice, allowing them to reflect on teaching actions observed and student learning freely.

The preparation occurred before a lesson was implemented and the critique phase followed the implementation of lessons that were developed collaboratively. Observations occurred as planned lessons were taught. During the preparation phase teachers hypothesized what may transpire in the course of implementing lessons as well as the students' reactions to ideas. All planned lessons were taught by the first author while teachers observed the group interactions. Following the lesson implementation, and during the last component of the cycle, the team critiqued the lessons and discussed applicability and adaptability to the individual classrooms.

The laboratory class cycle began with planning for the demonstration lessons. The teachers decided on the mathematical topic they wanted to examine as a team, according to the school syllabus; they discussed how they would teach the topic; they hypothesized and determined the relevant prior knowledge and experiences on which the students could draw to construct new knowledge; and they adapted or created mathematics lessons that built on prior knowledge and experiences and had the potential to foster the intended learning. The teachers then observed the professional developer teach the planned lesson during their common planning time. The teachers completed the cycle by reflecting and critiquing the demonstration lesson as a team. The teachers carefully unpacked the mathematics that needed to be taught, the level of thinking at which a majority of the students were engaged during the lesson, the students' responses, and ways in which the teaching supported or impeded the students' engagement with the tasks.

One complete laboratory class cycle consisted of four meetings within a month period during which three meetings were devoted to deliberating each of the relevant phases. The last meeting was devoted to discussing concepts or teaching ideas that may have aroused in the course of implementation. Altogether six laboratory class cycles were implemented in the study.

Grounding our work in the assumption that professional development programs should be implemented in or from practices (Ball & Cohen, 1999), in this study we examined one specific model of community of practice, the laboratory class cycle which consists of three components of collaborative planning, collaborative observing and critiquing, to trace how six teachers responded to immersing change through examining their own teaching practices. Our data collection and analysis focused on one key question: In what ways do teachers perceive the laboratory class cycle to contribute to their professional development?

Methodology

This report is part of a [1]larger study conducted in Dayspring Primary School. The school had block scheduling of classes. The teachers at each grade level had a period during the afternoon to meet and co-plan lessons and activities and to compare their students' work. The school system had previously adapted mastery learning, but new state standards were implemented during the year of the study. The professional development program lasted 2 years. One laboratory class cycle was conducted with second grade teachers during the first year of the program to familiarize them with the professional development structure. Data collection began in the second year of implementation.

Participants

The participants in this study consisted of 6 second grade teachers and a vice-principal at Dayspring Primary School. The teachers were [2]Mary, Ivy, Kay, Lana, Anna. Mary and Ivy had joined the program during the second year of the implementation. Linda was part of the team in the first year of the program and was promoted to the vice-principal of the school at the time of data collection.

Data Collection

Data sources consisted of individual face-to-face interviews with participants as well as the researchers' field notes. 49 interviews were conducted. Each interview lasted approximately 40 minutes. The first interview occurred before the program began. Its purpose was to elicit the teachers' beliefs about teaching and learning mathematics, to determine the approaches they commonly used in teaching mathematics, and to accumulate information about the professional development programs that had influenced them as mathematics teachers. Six interviews were conducted with each of the teachers immediately after each laboratory class cycle. The six interviews were semi-structured focused on participant's experience in the professional development program. The final interviews with the teachers were conducted after the program ended and were intended to help the teachers reflect on their teaching and learning as a result of the program. Thus each teacher participated in a total of eight interviews. The assistant principal took part in one interview at the end of the program in order to summarize her observations of the teachers' learning and teaching.

Data Analysis

In analysing the participants' ideas regarding the Laboratory Class, think aloud method (Brown & Rogers, 2002) was utilized. Interview data were classified into appropriate units for analysis, and "constant comparative analysis" was performed to identify patterns related to the participants'

[1] Another paper from the larger study appeared in Cheng & Ko (2009).
[2] Pseudonyms were assigned to the school and the participants to ensure confidentiality.

perceptions of the value of laboratory class cycle. Open coding, categorization, and verification of categorization then followed (Ezzy, 2002). First, excerpts from interview transcripts were sorted to reflect appropriation of the 3 components of the laboratory class cycle – planning, observing and critiquing. The data were then coded inductively to represent the major themes that emerged from the collection of interviews.

At each of the planning, observing, and critiquing stages, the content labelled, and the sorted coding data were collaboratively cross-checked by the researchers. Data with similar topics were catalogued to allow for generating an exhaustive list of labels. For example, in planning, the codes that emerged included confidence in teaching, opportunity to learn, opportunity to share teaching ideas, cater to students' learning, multiple solutions, try out ideas, feedback on lesson ideas, to name a few. At the end of the coding process, comments pertaining to each of the components were analysed and regrouped into "larger superordinate codes to capture the larger meaning of the group of codes" (Dickerson & Doerr, 2014, p. 716).

Findings

In this study, a community, including developers, was created to develop a practical program for the professional development of mathematics teachers, taking into account their philosophical and pedagogical backgrounds and values. Dewey formed a community within a laboratory school in connection with The University of Chicago to enrich human resources and to upgrade the professionalism of a school community (Baker, 1955). Similarly, Rodgers (2002) asserted that reflective thinking needs to occur through mutual interactions with others in a community. According to Rodgers, experience without interaction bears no fruit. Thus, in an effort to form a teacher inquiry community, we organized and implemented the Learning Circle Community (LCC), consisting of 3 cycles: planning, observing and criticizing. We identified the specific areas in each component that provided the teachers an opportunity to learn. In the following sections, we will first describe the participants' initial views of mathematics teaching and learning and then report on the ways in which the components in the laboratory class cycle contributed to their learning.

Views about Teaching Mathematics before The Program

Ivy, Macy and Anna were trained to use mastery learning in teaching mathematics. Ivy believed that students in this school could cope only with learning basic mathematical skills, and thus she covered only the basic skills with her students. She expressed that these skills were all that her students needed to master and that they could always learn how to think later. Lana believed that children needed to learn only facts and certain principles in mathematics. Anna and Macy had employed mastery learning techniques in

teaching mathematics for several years before the study. Both of the teachers stated that they loved organization, orderliness, structure, and control in their classroom. Anna believed that a majority of her students did not receive academic support at home. She told her students exactly what and how to do mathematics problems or tasks because many of the parents were illiterate or at least unable to help with their children's homework. Anna provided many opportunities for her students to complete exercise in school and avoided assigning students homework unless they were taught exactly how to do those problems. Mary and Ivy used the Internet frequently to search for ideas for teaching. Mary read professional and research articles about how children learn. She believed in the value of research; she also believed in using hands-on activities and manipulatives with younger children and did so in her first grade classroom. She used direct instruction with her second graders because she believed that they learned by being told how to do mathematics. She also believed that there was only one way to solve a mathematics problem.

Linda believed in developing students' mathematical thinking and in using questioning, manipulatives in helping students learn mathematics. Linda said, "Mastery learning is where you were taught an objective and you were retaught the objective, and you were given a paper-pencil test. And if you didn't pass the objective, you didn't master it. So you were retaught it." She thought that the mastery learning system had greatly influenced a few of the teachers who had been with the system for several years.

Figure 1 summarizes the teachers' perceptions of how they viewed the laboratory class cycle contributed to their own learning about teaching. Details on Figure 1 are offered the next section.

Planning

The teachers reported that they planned lessons on their own but that they occasionally shared lesson ideas with close friends in the schools prior to joining the program. The teachers also reported that they had not shared lesson ideas as a grade level because it was not a part of the culture of the school.

The interview data suggested that team-planning lessons provided the teachers a platform to deepen their pedagogies by helping them to connect theory and practice. For example, in laboratory class cycle 4, during the planning of a lesson on measurement, the team members discussed how their students would measure a given object if the object was not placed on the zero point. The teachers remarked that they had never thought about using such a question to stimulate students' thinking. Kay said that it was interesting to view measurement as subtraction. That is, the length of the object could be measured by subtracting the starting point from the ending point after placing the given object on a number line – distance between 2 points. Mary remarked that by discussing such problems, she was able to help her students figure out

how long an object was in multiple ways and to relate measurement to the number line.

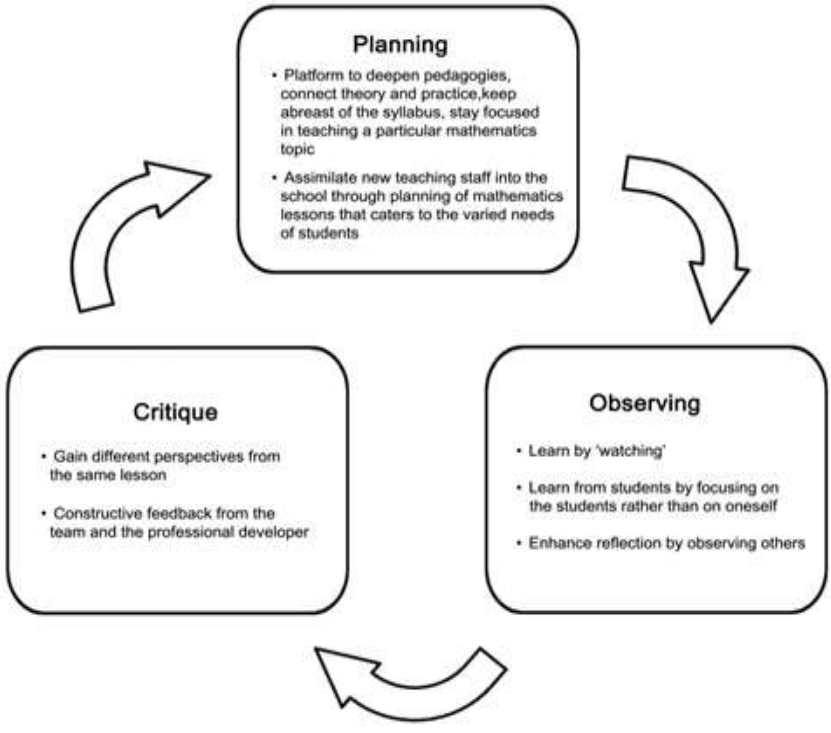

Figure 1. *Learning circle community.*

In the third interview, Anna stated that most of the professional development programs she had attended were incidental, with no follow up activities. She felt that planning lessons on particular mathematics topics as a group allowed her to put theory into practice.

> We need all the input with mathematics and we just never really focus on it very much … A couple of times they have done a couple of strands but they start something and they just [left]… continuation of it is important… You don't know whether you can handle real world until you try some of these things... (Anna, interview; Third interview)

Ivy shared the same view that planning the lessons as a team allowed for immediate application of theory into practice.

The interview data also suggested that the planning activities assisted Kay, a new member in the team, to cope with the challenge of teaching in a new environment. For example, while reflecting on the planning sessions, Kay remarked that before the study she had been unsure of herself as a new teacher in the school. With the planning sessions, Kay was able to discuss with the rest of the team members different ways students learned the content and to come up with teaching approaches in order to cater to the varied needs of students. Kay said that this knowledge made her feel more confident about

teaching again. On the other hand, Anna and Macy who were with the school for more than 5 years remarked that the planning sessions provided them the opportunity to learn "newer methods of teaching" from the "younger teachers" as they shared ideas about teaching a specific mathematics topic.

Based on her observation of classroom, Linda felt that those teachers who had previously relied heavily on drill-and-practice activities now were infusing more questioning and students' explanations in their lessons. Their students were also seen to take-up more active roles in their learning. "Instead of just looking at we are adding two-digit numbers today," Linda remarked that the teachers thought more deeply about how to conduct mathematics lessons and about the types of activities to include in the lessons beyond what the workbook offered. Linda thought that the teachers who had used the mastery learning approach for several years were the ones who seemed to have changed the most in terms of their lesson planning. The planning component shows potential in improving teachers' disposition to study and improve teaching. By sharing and honing such skills as a team, members assisted one another in understanding the changes and in conceptualizing how to apply those changes.

Observing

The program focused on using questioning to engage students in mathematical explanations and in examining correct or incorrect solutions to tasks. Although the teachers had previously used questioning techniques in their lessons, they reported that watching 'someone else' demonstrate questioning strategies encouraged them to try 'open' questions in their mathematics classes even when the students' responses were incorrect. Lana said, "Having the kids think about why their answers are right…so that they can tell me which one was right which one was wrong helped to promote mathematical thinking among them." Observing someone else teach lessons helped the teachers to *focus on their students' thinking processes*. It also helped them to realize developing students' thinking skills as an important component of a mathematics lesson. The observation phase served as a *mirror* for the teachers, allowing them to reflect more deeply on teaching and how children learn mathematics.

The observation component also helped the teachers to reflect on their *beliefs about how mathematics should be taught and their expectations of their students.* Lana remarked that mathematics should be taught as "a thinking exercise, or an exercise in thinking." Reflecting on the observation component, Anna commented that she thought her students were not able to cope with mathematics lessons that required students to explain and to reason. After observing her students' capability to communicate their mathematical ideas, she realized that she needed to set higher performance expectations for her students. Anna also commented that oftentimes she would answer her own questions in class because she was impatient. The observation component

reminded her of the importance of giving the students time to think and the value of asking them to share their responses. Kay reflected that teaching does not only involve transmission of information, but also probing students' thinking and asking students to communicate their ideas. Kay expressed "I thought since I have all the mathematics knowledge in me, I'll just give it to them and in my way. Now I see … here is not just my way … I can ask them why they did it this way … lately I have … [the students] go up there [in front of the class] and tell the class."

As the data suggested, the observation component allowed the teachers to re-examine their beliefs and practices about teaching and learning mathematics. We view the observation component as an example of assisted performance because the teachers were assisted in their growth by observing students.

Critiquing

The teachers remarked that having the team criticize the lessons they observed was beneficial, as they were able to *gain different perspectives on the same lesson*. They learned how to cater their instructions to the varied needs of their students. Macy, Mary and Kay attributed their increased ability to experiment with new teaching approaches to the opportunities to receive constructive feedback without being ridiculed. Macy said the critique was useful because the teachers were "listening to other people, and they let other people know that they don't think everything they are doing is the only way [for it] to be done." Linda thought that the safe and respectful environment of collaborative reflection offered the teachers a chance to discuss issues freely and assured them that their comments would not be used against them later.

The critique component provided the teachers a *platform to strengthen their skills and their dispositions to study and improve teaching*. We view the critique component as an example of assisted performance because the teachers and the professional developer helped one another to prepare for new teaching approaches. The critique component engaged teachers in critical reflective thinking as a community

Coping with Change

Anna. Anna had been teaching for 15 years. She was the leader of the second-grade team. However, she was the only teacher who said she had been afraid to try out new ideas in her lessons. She had assumed that the new methods would not work for her students. She thought also that trying new methods of teaching mathematics might cause her to lose structure and control. "I'm a person that likes structure and to do the same thing ... I'm not really comfortable with change…If I think something works, I tend to do it without trying something else, because I would fail (Anna, fifth interview). Anna said that after the second laboratory class cycle she felt *braver* about trying new approaches in her lessons. In the second cycle, the teachers planned, observed and critiqued a lesson that

required students to form number bonds. Reflecting on the experience, Anna said that she had learned from the second lesson even though it had not worked as planned.

> Like the number bond idea didn't work as well as…we thought it would. But still, seeing that it's something different that I might use somewhere or sometimes or with some kids…I think that has helped me to kind of step out of the box and think of things a little bit differently. (Anna, fifth interview)

Ivy. Ivy was new to the school and had no experience teaching second grade prior to the study. Ivy claimed that participation in the program not only prepared her to teach younger children but also assimilated her into the second-grade team. Ivy said, "I have never taught the 2nd graders before … so that helps me if we can work together … before they didn't know me, they didn't know what I can contribute so now I feel like I contribute more to the group".

Conclusion

This study investigated the utility of laboratory class cycle in advancing teachers' development regarding instructional practice. The laboratory class cycle consisted of three components: Planning, observing and critiquing. The teachers in this study found the three components of the laboratory class cycle helpful in supporting their teaching and learning to teach. We believe that these three components offer an example of what assisted performance might look like in a school-based professional development program. The three components of the model extended and refined teachers' repertoire with curriculum, and instruction. They also strengthened their skills and increased their desire to improve their teaching.

In this study, each of the three components helped the teachers to learn or to try something that they had not tried before the program. The planning component provided the teachers opportunities to share and assemble teaching ideas they already possessed. Specifically, the planning component increased teachers' efficacy towards teaching in a new school or new environment. The observation component acted as a mirror for the teachers allowing them to reflect upon their own teaching practices. It also enabled them to re-examine their beliefs about learning and teaching. The critique phase encouraged the teachers to engage in critical reflection by encouraging them to anticipate how students might react and respond to lessons. As such, the "Professional development" as implemented in the Learning Cycle Model increased teachers' cognitive skills (Park et al., 2008).

The teaming model of the laboratory class cycle provided the teachers with a systematic structure to examine their teaching practices collaboratively. The teachers respected one another and the professional developers were there

to mediate any potential conflicts or differences in views[3]. Additionally, the professional developer took on the task of demonstrating the planned lessons. This feature enabled the teachers to fully focus on the planning, observing and critiquing of mathematics lessons.

The small sample size of the participants in the study certainly limits the generalizability of the efficacy of the laboratory class cycle as a structure for teacher change. More data sources may be required to capture the full complexity of the effect of the laboratory class cycle. Nevertheless, findings suggest that by providing a structure for teams of teachers to examine their existing teaching practices and to experiment with various teaching ideas, teachers are more likely to grow.

References

Baker, M. C. (1955). *Foundations of John Dewey's educational theory*. New York, NY: King's Crown Press.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). San Francisco, CA: Jossey-Bass.

Brown, J. D., & Rogers, T. S. (2002*). Doing second language research*. New York, NY: Oxford University Press.

Carter, K. (1990). Teachers' knowledge and learning to teach. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 291–310). New York, NY: Macmillan.

Cheng, L.P. (2014). Teaching for mathematical abstraction. In, P. C. Toh, T. L. Toh, & B. Kaur (Eds.), *Learning experiences to promote mathematics learning* (pp. 131–152). Singapore: World Scientific.

Cheng, L. P. & Ko, H. K. (2009). Teacher-team development in a school-based professional development program. *The Mathematics Educator, 19*(1), 8–17.

Crotty, T., & Allyn, D. (2001). *Evaluating student reflections*. River Falls, WI: University of Wisconsin. Retrieved from ERIC document Reproduction Service No. ED459174.

Demulder, E. K., & Rigsby, L. C. (2003). Teachers' voices on reflective practice. *Reflective Practice, 4*(3), 267–290.

Dewey, J. (1904). The relation of theory to practice in education. In C.A. McMurry (Ed.), *The relation of theory to practice in the education of teachers: The third yearbook of the national society for the scientific study of education*. Chicago, IL: University of Chicago Press.

Dewey, J. (1944). *Democracy and education*. New York, NY: Free Press. (Original work published 1916)

[3] The teachers progressed through the five stages of team development as a result of the professional development experience (Cheng and Ko, 2009).

Dickerson, D. S., & Doerr, H. M. (2014). High school mathematics teachers' perspectives on the purposes of mathematical proof in school mathematics. *Mathematics Education Research Journal*, *26*(4), 711–734.

Eisner, E. W. (1988). The primacy of experience and the politics of method. *Educational Researcher, 17*(5), 23–34.

Ezzy, D. (2002). *Qualitative analysis*: *Practice and innovation.* London, UK: Routledge.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*, 1113–1055.

Freeman, D., & Richards, J. C. (Eds.). (1996). *Teacher learning in language teaching*. Cambridge, UK: Cambridge University Press.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record, 103*, 942–1012.

Gutierrez, R. (2000). Advancing African American, urban youth in mathematics: Unpacking the success of one mathematics department. *American Journal of Education, 109*, 63-111.

Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development. In L. Darling-Hammond, & G. Sykes (Eds.), *Teaching as a learning profession* (pp. 127–150). San Francisco, CA: Jossey-Bass.

Lee. J. H. (2012). The characteristics of reflective teacher based on Dewey's concept of reflective thinking. *Korean Journal of Elementary Education, 23*(2), 17–34.

Lewis, C., Perry, R., & Hurd, J. (2009). Improving mathematics instruction through lesson study: A theoretical model and North American case. *Journal of Mathematics Teacher Education, 12*, 285–304.

Little, J. W. (2002). Locating learning in teachers' communities of practice: Opening up problems of analysis in records of everyday work. *Teaching and Teacher Education, 18,* 917–946.

Mewborn, D. S., & Stinson, D. W. (2007). Learning to teach as assisted performance. *Teachers College Record, 109*, 1457–1487.

Olson, M. R. (1995). Conceptualizing narrative authority: Implications for teacher education. *Teaching & Teacher Education, 11*(2), 119–135.

Palinscar, A. S., Magnusson, S. J., Marano, N., Ford, D., & Brown, N. (1998). Designing a community of practice: Principles and practices of the GIsML community. *Teaching and Teacher Education, 14*, 5–19.

Park. S. R., Han. S. H., & Lee. M. J. (2008). Reconsideration of the research trend for the reflection on teaching. *Journal of Learner-Centered Curriculum and Instruction, 8*(2), 403–422.

Rodgers. C. (2002). Defining reflection: Another look at John Dewey and reflective thinking. *Teachers College Record, 104*(4), 842–866.

Shrum, J. L., & Glisan, E. W. (2005). *Teacher's handbook: Contextualized language instruction* (3rd ed.). Boston, MA: Thomson Heinle.

Smith, M. S. (2001). *Practice-based professional development for teachers of mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Sztajn, P., Hackenberg, A. J., & White, D. Y., & Allexsaht-Snider, M. (2007). Mathematics professional development for elementary teachers: Building trust within a school-based mathematics education community. *Teaching and Teacher Education, 23*, 970–984.

Truscott, D. M., & Truscott, S. D. (2004). A professional development model for the positive practice of school-based reading consultation. *Psychology in the Schools, 41*(1), 51–65.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination on contemporary professional development. *Review of Research in Education, 24*, 173–209.

Wolfensberger, B., Piniel, J., Canella, C., & Kyburz-Graber, R. (2010). The challenge of involvement in reflective teaching: Three case studies from a teacher education project on conducting classroom discussion on socio-scientific issues. *Teaching and Teacher Education, 26*, 714–721.

Authors:
Lu Pien Cheng
National Institute of Education, Singapore
Email: lupien.cheng@nie.edu.sg

Ho Kyoung Ko
Ajou University, Korea
Email: kohoh@ajou.ac.kr